A THESIS FOR THE MASTER DEGREE OF FOREST SCIENCE

Citizens' preferences for ecosystem services provided by urban forests in Beijing, China

도시림 생태계 서비스에 대한 베이징 시민의 선호도

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Abstract

Rapid urbanization creates tremendous pressure on the natural environment. It also causes many ecological problems, especially in a city and its surrounding areas. Developing urban forest is considered an important strategy for promoting sustainable urban development. In other words, urban forests play a very significant role in urban ecosystems. They provide a variety of important ecosystem services (hereafter referred to as ESs) for people. These include carbon sequestration, air quality improvement, water storage, recreation and aesthetic services. Although the role of urban forests in ecological environment construction is of great significance, the urban forest per capita in Beijing is limited and cannot meet public needs. Policy options to meet various public needs, improve distribution and supply of ecosystem services, and minimize the conflict between policy makers and ecosystem beneficiaries by analyzing public preferences of urban forests in terms of various ecosystem services are necessary. This study aims to the Beijing citizens' preferences over various options of urban forest management strategies. The literature review and expert Delphi method were employed to rank the importance of 18 ecosystem services and to classify the ecosystem services of urban forests into 6 categories: (1) fresh water, (2) noise reduction, (3) moderation of extreme events, (4) air quality regulation, (5) species diversity and wildlife habitat, and (6) recreation and spiritual experience.

The main choice experiment survey was conducted in October 2017 and a total of 483 valid questionnaires were analyzed. The subjects of this experiment were citizens older than 19 years old, have lived in Beijing for more than 1 year and have visited any one of the urban forests located in Beijing more than once during 2016. The results are as follows: Firstly, the air quality regulation ES is considered as the most influential service for Beijing citizens in terms of their choice of urban forest. Beijing citizens were willing to pay 85 RMB/year and 264 RMB/year to invest in urban forest expansion for improving air quality from low to middle and from middle to high, respectively. In addition, Beijing citizens regarded the fresh water ES as the second-most important ES. Secondly, citizens with a high monthly household income are more willing to pay for urban forest ESs. Thirdly, apartment owners are willing to pay municipality tax as compared to non-apartment owners. Fourthly, citizens emotionally connected to Beijing tend to have willingness to pay more of municipality tax. The results indicate that citizens are willing to pay a tax that can support urban forestry for air quality improvement. This research suggests for urban environmental policy makers in Beijing to pay more attention to air quality regulation function of forests. It is also recommended to design and manage urban forests to satisfy its visitors.

Keywords : urban forest, ecosystem service, citizens' preferences, choice experiment, Beijing

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1.1 Research Background

1.1.1 Urban Forests

The world's urban population has undergone significant growth. It has increased from 746 million in 1950 to 3.9 billion in 2014 (United Nations, 2014). By 2016, the proportion of this urban population is 54.3% of the total population of the world (The World Bank, 2017). DeFries (2010) mentioned that the world's population growth rates are slow, but urban growth is far outpacing rural growth. China is the most populous country in the world. Rapid economic development has resulted in dramatic changes in its urban population. Since China's reform and opening-up, it has experienced the largest urbanization in the history of the world, with its urbanization level rising rapidly from 17.9% in 1978 to 56.1% in 2015 (Deng and Fan, 2016). Beijing is China's capital and its political and cultural center. In 2016, its population was 21.729 million (Beijing Statistical Information Net).

Rapid urbanization creates tremendous pressure on the natural environment. It also causes many ecological problems, especially in the city and surrounding areas (Wu and Wang, 2016). Nowak (2006)'s article demonstrated that urban tree management could provide an effective way to improve urban air quality in the United States. The urban forest, which

includes vegetation along urban streets and in urban parks, woodlots, abandoned sites, and residential areas, can constitute an important percent of a nation's tree cover (Alvey, 2006). In many countries, developing urban forest is an important strategy for a city's sustainable development (Li and Wang, 2005). Urban forests play a very significant role in urban ecosystems through providing a variety of important ecosystem services (hereafter referred to as ESs) for people, such as carbon storage and carbon sequestration (Dwyer, 1992; Nowak, 2000), air quality improvement (Dwyer, 1992; McPherson, 1997, Nowak, 2000), water storage (Livesley, 2016), recreation and aesthetic services (Chen, 2008; Morar, 2014), microclimate regulation (Chen, 2008), rainwater retention (Chen, 2008), health and psychological services (Dwyer, 1992; Chen, 2008; Morar, 2014), biodiversity conservation (Chen, 2008), education and sites for scientific research (Chen, 2008), energy conservation (McPherson, 1997), wildlife habitats (Chen, 2008), and noise reduction (Aylor, 1972; Dwyer, 1992; Morar, 2014).

1.1.2 Beijing's Situation

Beijing is the capital city of China. It has a population of 21.729 million as of 2016. Its geographical center is located at 39° 92' N and 116° 46' E. It has a typically continental monsoon climate with four different seasons. Most of its precipitation is concentrated in July and August. Its frost-free period is about 180 days. The area administrated by the Beijing municipal government measures 16,807 km². Traditionally, the four

central city districts (Xuanwu, Xicheng, Chongwen, and Dongcheng) plus parts of three suburban districts (Haidian, Fengtai, and Chaoyang) are viewed as the central city (Yang and Gong, 2008) (Fig. 1).

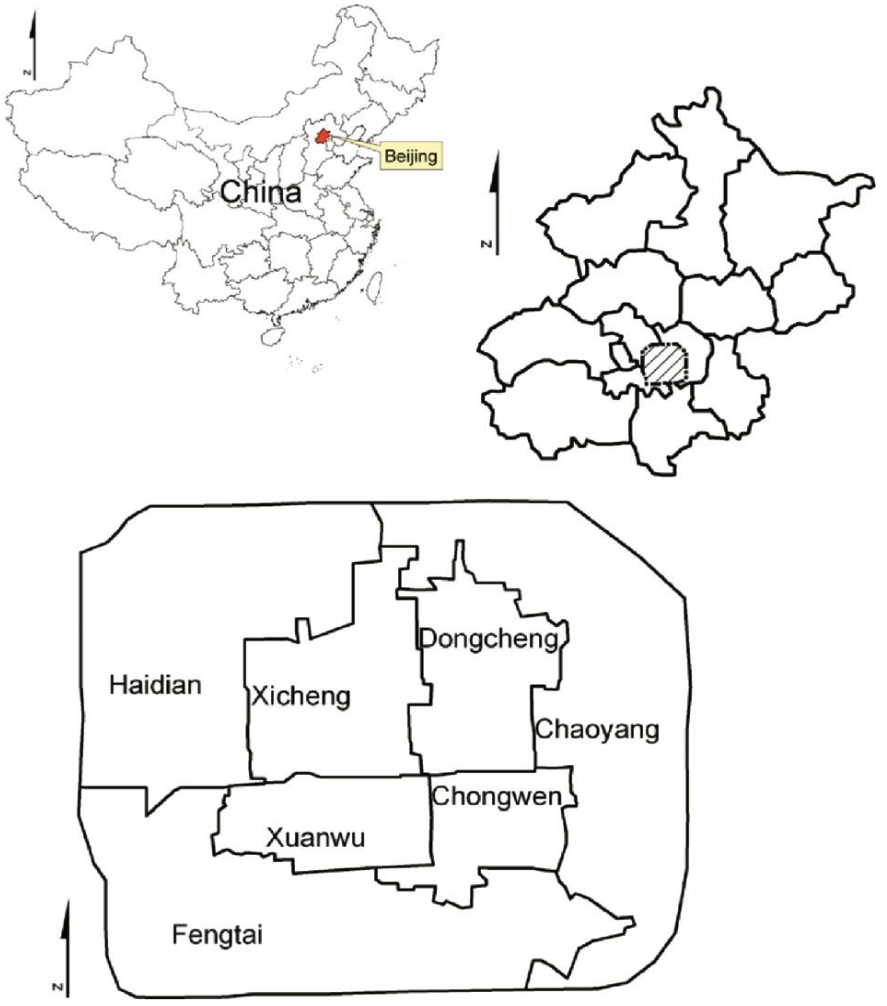


Fig. 1 The central city of Beijing map (Yang and Gong, 2008)

In 2015, Beijing's GDP was 2.29686 trillion RMB. Calculated based on its resident population, its per capita GDP reached 106284 RMB. By

the end of 2016, Beijing's resident population was 21.729 million. In 2016, per capita disposable income in Beijing reached 52,530 RMB, and the total retail sales of social consumer goods reached 1.10051 trillion RMB (Beijing Statistical Information Net). The area of the central city is about 305 km^2 and constitutes the major portion of the city's built-up area. A large number of citizens benefit from ecosystem services provided by urban forests, so this study focused on the central city area where about 4.5 million citizens live.

There were 25 smog days in Beijing during January 2013. The average visibility was 9.2 km, and the PM2.5 measurement reached a level of more than 800 $\mu g/m^3$. The number of smog days was 2.2 times more than during the same period of an ordinary year (11.4 days). This was the most severe pollution level since 1954 (Shi and Sun, 2014). There have been frequent occurrences of smoggy weather in China since January 2013. This has become a pressing issue for the general public. Beijing, due to its unique natural situation and socioeconomic background, has become one of China's inland areas seriously affected by atmospheric pollution (Zhang and Chen, 2017). At the end of 2015, Beijing was attacked by heavy smog, and announced two consecutive red alerts (Peng and Zhang, 2016). Beijing's air quality deteriorated. The smog not only affected people's health and quality of life, but also had a negative effect on tourism (Peng and Guo, 2016). Statistics from the National Tourism Administration showed that the number of inbound tourists in Beijing from February 2013 to January 2014 fell about 30%. This demonstrates

that smog led to huge losses in economic development for Beijing's citizens.

Due to long-term development and construction projects, Beijing's ecosystem has reached a state of degradation. Its natural resources have also faced the problem of excessive demand. Speaking in terms of water conservation and sand protection, Beijing should develop urban forests to expand its environmental capacity and ecological space.

1.1.3 Beijing Urban Forests

Urban green space in China is divided into 5 parts. This includes (1) urban park green space, (2) production green space, (3) protection green space, (4) attached green space and (5) other green space. Urban forest is defined as forest or trees planted and managed in urban areas for health, rest, entertainment and emotional regulation of their residents (excluding remote areas). It is also the general term for urban green space where the forest is its main part.

Table 1 Classification of urban green space (urban forest)

Type	Description
Urban park green space	It is open to the public with leisure as the main function,. Its functions include ecology, landscaping and disaster prevention.
Production green space	It provides urban greenery and includes nursery stock, flowers, a seed nursery, flower beds, and grass beds.
Protection green space	It plays a role in health, isolation, and security protection in a city's green spaces,. This includes health quarantine zones, urban high-voltage corridor green belts, road protection green space, buffer zones, and windbreak belts.

Attached green space	It includes various types of land attached to green spaces of urban construction land outside. This includes residential land, public facility land, industrial land, storage land, transportation land, land for roads and squares, municipal facility land and special sites for green space.
Other green space	It directly influences the quality of the urban ecological environment, residents' leisure life, urban landscape, and biodiversity conservation. It includes scenic areas, water conservation areas, country parks, nature reserves, forest parks, scenic forest land, urban greening belts, zoos, wetlands and green land recovered from landfills.

[Source: Ministry of Construction of People's Republic of China, 2002]

Zheng (2014) indicated that Beijing's urban forests have several problems. These include the presently poor stand quality, along with a low forest coverage rate per capita and relatively backward management level.

Table 2 Change of forest resources in Beijing

Year	Forest area /hm^2	Woodland area /hm^2	Stock volume /m^3	Forest volume /m^3	Forest coverage rate /%	Woodland coverage rate /%
2010	666,050.67	1,047,012.09	18,547,000	14,353,900	37.00	53.0
2011	673,411.77	1,047,847.05	18,993,700	14,687,200	37.60	54.0
2012	691,341.11	1,062,302.85	19,433,000	14,990,400	38.60	55.5
2013	716,456.08	1,082,264.85	19,934,200	15,367,700	40.13	57.4
2014	734,530.56	1,081,443.57	21,091,400	16,698,800	41.00	58.4
2015	744,956.06	1,089,534.30	21,493,400	17,010,600	41.60	59.0
2016	756,000.69	1,091,600.41	21,799,600	17,245,500	42.30	59.3

[Source: Beijing municipal bureau of landscape and forestry]

Beijing has grown to include more than 1,100 kinds of parks. Its registered ones grew from 96 in 2000 to 387 in 2013. The city's park areas also increased by nearly threefold from 4,192 hectares to 12,138 hectares. These include scenic areas, forest parks, historical gardens, country parks and wetland parks, which reached respective amounts of 27, 31, 21, 50 and 8. Beijing has a total amount of 34 state-owned forest farms with a total area is 60,864.78 hectares. Beijing has a total amount of 31 forest parks with a total area of 96,599.67 hectares. It has a total of 14 forest parks, which are state-owned forest farms.

Table 3 Classification of urban park in Beijing

Classification standard	Category	Specific name
Management level	National key park	
	Municipal key park	
	General park	
Type	Comprehensive park	Municipal park, regional park, town park
	Community park	Town community park, countryside community park
	Theme park	Historical garden, heritage park, zoological park, botanical garden, amusement park, country park, waterfront park, forest park, wetland park, other theme parks

[Source: Beijing municipal bureau of landscape and forestry]

The World Health Organization (WHO) has recommended that an "international city is a healthy city, where its green space area per capita is

40-60 square meters and its park green space area per capita is 20 square meters". Compared with these requirements, Beijing is still lacking in this regard, as it has a low urban park green space per capita (16 square meters).

Table 4 The forest coverage rate of Beijing and other world cities in 2012

City	Beijing	Shanghai	Tokyo	London	Paris	New York
Forest coverage rate /%	14.85	12.58	37.80	34.80	65.00	24.00

[Source: Analysis on the status and suggestions of urban forestry to in Beijing (Zheng, 2014)]

Especially in urban areas, it is difficult to increase urban park green space due to the intensive level of development and construction. A service radius of 500 square meters for urban park green space covers only 73.8% of residential areas. There are also blind areas of nearly 80 square meters, within which it is difficult to effectively ease the heat island effect. The area and density per capita of Tokyo's park green space is 3 times and 1.8 times respectively that of Beijing. The urban green space per capita of 22 major cities in the Netherlands is about 228 m^2 (Luo and Bao, 2004).

Table 5 Urban green index system list

No.	Index	In 2015	In 2020

No.	Index	In 2015	In 2020
1	Forest coverage rate（%）	41.6	44
2	Forest coverage rate in plain area（%）	25	30
3	Woodland coverage rate（%）	59	60
4	Urban green coverage rate（%）	48	48.5
5	Urban park green space coverage rate of 500 meters service radius（%）	67.2	85
6	Urban park green space per capita (by permanent population statistics) (m^2/person)	16	16.5
7	Urban green space per capita (by permanent population statistics) (m^2/person)	39.84	
8	Forest volume (ten thousand m^3)	1670	1770
9	Forest ecosystem services value (one hundred million RMB)	6938	7455

[Source: Beijing municipal bureau of landscape and forestry (Note: the city's forest coverage rate is the outline index of the city's national economic and social development)]

Urban forestry is different from traditional forestry in policy-making, as it is expressed through the public's participation in negotiations. That is to say, urban forestry is closely associated with the public (Luo and Bao, 2004). Based on these aspects of Beijing's background, we chose it as our study area. Our focus was on 2 types of urban forests - urban parks and urban country parks. We believe that due

to the low urban park green space per capita in Beijing, more attention should be paid to the designing and managing of urban parks.

Table 6 Status of Beijing green resources in 2016

Category	Area/ha.	Specific category	Area/ha.
Urban park green space	30,068.57	Park	18,814.50
		Community park	1,024.49
		Street green space	3,526.18
		Other park green space	6,703.40
Production green space	1,691.38		
Protection green space	16,775.91		
Attached green space	33,403.49	Residential green space	11,558.48
		Road green space	10,108.46
		Unit attached green space	11,601.17
		Other attached green space	135.38
Other green space	173.20		

[Source: Beijing municipal bureau of landscape and forestry]

1.2 Rationale and Significance

The period of the Thirteenth Five-Year Plan (2016-2020) is an important time for building a prosperous society in a comprehensive way and constructing an ecological civilization and beautiful China. It is also the crucial period during which Beijing is supposed to achieve the strategic goal of becoming an international first-class, harmonious and livable city. Urban forest plays an essential role in creating an ecological environment, promoting capital growth, and especially in terms of the maintenance of ecological security and addressing climate change. In order to effectively design and manage urban forests, more attention

should be paid to effectively promoting ESs to citizens, along with educating them regarding urban forests. It is important to research Beijing citizens' preferences regarding urban forests in terms of diverse ESs. There are two reasons for this: it helps maximize citizens' satisfaction, and also minimizes conflicts between policy makers and ESs. Meeting Beijing citizens' needs based on their socio-demographic characteristics along with improving the distribution and supply of ESs should be preceded by selecting an accurate policy target. Randomly selecting Beijing residents can prove ineffective if they have never visited any of the city's 50 urban country parks, 46 urban parks, 20 nature reserves or 24 forest parks.

This study's primary aim is to examine the public preference regarding urban forests in terms of various ESs in Beijing. It also intends to determine if there is a difference in public preferences regarding diverse urban forest ESs based on socio-demographic characteristics. It is likely that Beijing citizens with different demographic characteristics would have needs different from those living near urban ESs. Understanding Beijing citizens' perspectives of urban forest ESs will provide policy options for meeting the public's needs, improve the distribution and supply of ESs, and minimize conflicts between policy makers and ESs. It would also help Beijing work towards its strategic goal of becoming an international first-class, harmonious, sustainable and livable city.

1.3 Problem Statement

The urban forests' role in ecological environment construction is significant. However, there is a limited amount of urban forest per capita in Beijing. Target-specific policy measures are needed to effectively manage and construct urban forests that meet public needs for urban ESs. However, little is known about Beijing citizens' preferences regarding various ESs in urban forests from their own perspective.

1.4 Research Objectives

To provide policy options to meet various needs of the public and improve the distribution and supply of ESs.

Specific objectives:

1) To reorganize the present ecosystem services and collect opinions of experts in the field as a research basis.

2) To find out if there is a difference in public preferences regarding diverse ESs in Beijing's urban forests.

3) To analyze the preferences of Beijing citizens based on their socio-demographic characteristics regarding various ESs in urban forests.

1.5 Research Questions

1) Do Beijing citizens prefer an apartment or non-apartment dwelling related to the attribute level for each ES?

2) What is the most prevalent preference of Beijing citizens regarding various ESs in urban parks?

3) How willing are Beijing citizens to pay for various ESs in urban parks?

1.6 Hypotheses

1) The preferences for the attribute level of each urban forest ES of Beijing citizens are different among the citizen by their residence type, specifically between those who own their own apartments and those who do not.

2) Beijing citizens regard air quality improvement as the most important service if forest ecosystems when choosing between one or another type of urban forest management strategies.

3) Citizens with a high monthly household income are positively related to a willingness to pay a municipality tax as compared to low income citizens.

4) Citizens with emotional connections to Beijing are related to a willingness to pay a municipality tax.

1.7 Organization of Thesis

The following describes the methods of achieving the goal of this study:

Chapter 2 is a literature review of different types of urban ecosystem services. It provides the main ESs from 17 types of individual ESs (TEEB, 2011) of urban forests ESs. In addition, based on Aylor (1979)

and Morar (2014), noise reduction is one of the urban forest ESs.

Chapter 3 introduces the Delphi analysis, choice experiment methodology and the preparation for the main choice experiments field survey. It also includes the results of three other online surveys as part of the experiment design for the main choice experiments questionnaire.

1) The first online expert's survey ranks the importance of ESs.

2) The second online expert's survey arranges 13 ESs into 6 groups.

3) The final online expert's survey defines the urban forest ES attributes and attribute levels.

Chapter 4 details the results of the field survey in Beijing on 25 October 2017. This survey indicates Beijing respondents' socio-demographic characteristics and their willingness to pay for various urban forest ESs.

Chapter 5 concludes this thesis by discussing the results, providing opinions regarding the construction of urban forest ESs for government purposes, and explains the limitations of this research.

Chapter 2. Literature review

Ecosystem services can be divided into four categories: provisioning services, regulating services, habitat (or supporting) services, and cultural services. There are 18 types of individual ESs relevant to cities (TEEB, 2011; Aylor, 1979; Morar, 2014). These ESs can be grouped into four broad categories including 1) provisioning services, 2) regulating services, 3) habitat (or supporting) services, and 4) cultural services. The descriptions of each type of forest ESs are illustrated with examples below.

2.1 Provisioning Services

There are four ESs providing materials and energy including food, raw materials for industries, fresh water, and medicinal resources.

2.1.1 Food Supply

Urban forest ecosystem provides conditions for growth of food resource. Food resource is mainly obtained from managed agriculture ecosystem, but forest also can produce available food resource.

For example, urban garden in Havana, Cuba produces a considerable chunk of food supply of the urban residents including 8,500 tons of crops, 7.5 million of eggs and 3,650 tons of meat (Altieri, 1999).

2.1.2 Raw Materials Provision

Urban forest ecosystem supply various raw materials for construction and fuels, from wild or farming planet seeds to log, biofuel, plant-based oil, and etc.

For example, rubber, latex, brawly, planet-based oil and any other similar non-wood forest products are very important for the livelihood (Roe, 2002).

2.1.3 Fresh Water Supply

Urban forest ecosystem can ensure flow, conservation and purification of water and play important role in the supply of drinking water. Grass, trees and forest can exert influence the amount of available water.

For example, in inferred value of ecosystem service of Fynbos mountain zone (4 km^2) in Republic of South Africa, water production is deemed to be most worthy. And the worth is supposed to reach up to 4.2 million ~ 66.6 million dollars depending on the management method (Higgens, 1997).

2.1.4 Medicinal Resources Provision

Biologically diverse urban forest ecosystem can provide raw material of medicine industry and numerous plants used as traditional medicine.

For example, 80% of the world population relies on the medicine made by traditional medical herb (WHO, 2002). Annual revenue of medicine based on natural materials reach 57 billion dollars (Kaimowitz, 2005).

2.2 Regulating Services

The ecosystem services can regulate the quality of air and soil and prevent natural disasters and diseases, etc.

2.2.1 Local Climate and Air Quality Regulation

Urban forest can exert influence on the rainfall and available water capacity of the region. Trees and grassland can reduce the temperature of urban area and play a role in regulating air quality by removing pollutant in the atmosphere.

For example, per ha of Cascine Park of Italy maintains the capacity of removing 69~72.4 kg pollutant. Besides macroparticle pollutant, and other harmful waste gases including CO_2, O_3, CO, SO_2, NO also can be removed (Paoletti, 2011).

2.2.2 Carbon sequestration and storage

Urban forest ecosystem can fix greenhouse gas so that regulating earth climate. Growth of trees and plants can decrease the level of carbon dioxide in the atmosphere and fix carbon in the plant tissue effectively.

For example, annual carbon fixation amount of trees in urban forest in U.S.A. can reach up to 2.28 million tons. The quantity is similar to that of carbon exhaled by all of the population of U.S.A. in 5 days and this kind of fixation servicecan bring in worth of 460 million dollars (Nowak & Crane, 2002).

2.2.3 Moderation of Extreme Events

Organisms in the urban forest ecosystem can create cushion for the natural disasters and reduce the loss caused by the extreme weathers and disasters, including flood, violent storm, tsunami, landslide and etc.

For example, take city of Napa in California of U.S.A. as example, as the surrounding of the city is made up of seashore, swamp and wetland, natural capacity of restoring are supposed to regulate flood effectively (Almack, 2010).

2.2.4 Waste-water Treatment

Ecosystem like wetland and etc. could filtrate waste-water. Most of the waste-water can be decomposed by the microorganisms in the soil. Through the process of decomposition, pathogenic bacteria can be removed and the level of nutrition and pollutant can also be decreased.

For example, it is supposed that about $785~$34,700 per ha of wetland in Louisiana of U.S.A. can be saved. And it is found that wetland is also may be used for resolution to wastewater treatment (Breaux, 1995).

2.2.5 Erosion Prevention and Maintenance of Soil Fertility

Grass and trees can prevent soil erosion so that providing necessary control service. Soil fertility is essential for plant growth and agriculture, so that properly acting ecosystem can provide soil containing essential nutrition for plant growth.

For example, it is supposed that according to allowable rate in U.S.A., whole necessary investment amount for preventing soil erosion has reached 8.4 billion dollars. And annual loss caused by soil erosion reaches up to 44 billion dollars. That means every 1 dollar investment can bring in 5.24 dollars of reducing the loss (Pimentel, 1995).

2.2.6 Pollination

Insects and wind can provide water for growth of essential plants, including fruits, vegetables and seeds. And water from animals, including insects, birds and bats is another provided ecosystem service.

For example, among 115 types of main food crops, 87 types of commercial crops, which are significant as cocoa and coffee, rely on the water from other plants or animals (Klein, 2007).

2.2.7 Biological Control

Urban forests are important in preventing diseases caused by plants, animals, pests and media. Urban forests ecosystems control pests and diseases through the activities of predators and parasites. Nature controls all the activities of birds, bats, flies, wasps, frogs and virus.

For example, the breeding of water hyacinth is controlled by three natural enemies of water hyacinth in the south of Benin. The value of sustaining ecosystem health is estimated to be 2.09 million dollars in current value, while the accumulated value is estimated to be 260 million dollars (Benefit 124:1) (De Groot, 2003).

2.2.8 Noise reduction

In the urban forest ecosystem, leafs, branches and twigs of trees can absorb noise. In addition, sound of wind through pine leafs, sound of shaking of the oak leafs or any other self-made sound can reduce noise levels.

For example, the stems of the hemlock, pine, and brush all can reduce noise by about 5 dB/100 ft at 4000Hz (Aylor, 1972).

2.3 Habitat or Supporting Services

This service becomes the crutch of three other kinds of services. Ecosystems provide space for plants and animals to live and maintain the diversity of plants and animals.

2.3.1 Habitats for Species

Urban forests ecosystem provides all which are necessary for animals to live such as food, water and habitat. When all migrant species move, various habitats are provided, which may be necessary for the life cycle of a species.

For example, the loss of habitat is a major threat to European butterflies and may cause extinction of some species. Habitat loss is mostly due to agricultural activities, climate change, forest fires and expansion of tourism (IUCN, 2010).

2.3.2 Maintenance of Genetic Diversity

Genetic diversity distinguishes different species and provides the basis for locally appropriate species and gene groups. The richly dense areas of many species are genetically diverse, and these areas are known to be major biodiversity areas.

For example, in the Philippines, initiatives for the protection of rice species have caused the development of species, better harvesting and better seed supply and it significantly reduces costs than traditional plant breeding (Searice, 2007).

2.4 Culture Services

It includes immaterial benefits that people gain from the contact with ecosystems. Aesthetic, mental and psychological benefits are included in the services.

2.4.1 Recreation and Mental and Physical Health

Walking and exercising in green spaces like urban forests are good forms of physical activity and help people relax. There is a growing

awareness of the role of green spaces in maintaining mental and physical health.

For example, according to the result of monetary value of ecosystem services in relation to urban green spaces based on the research on nine cities in China and one city in the USA, the value of seven ecosystem services is estimated at $29,475 per ha per year, while that of 'recreation and convenient facilities' is $5,882 and that of 'health impact' is $17,548 (Elmqvist, 2015).

2.4.2 Tourism

Urban forest ecosystems and biodiversity play an important role in the tourism sector. It provides considerable economic benefits and is an important source of income for many countries.

For example, the value of Hawaii coral reefs is estimated at 97 million dollars annually through the travel cost method (Cesar & Van Beukering, 2004).

2.4.3 Aesthetic Appreciation and Inspiration for Culture, Art and Design

Language, knowledge and the natural environment have been closely linked through human history. It has been a source of inspiration for many parts of human art and culture. It also provides more and more inspiration to the field of science.

For example, prehistoric rock paintings in southern Africa,

Australia and Europe and many other examples from around the world demonstrate how nature inspired art and culture in the early days of human history. Modern culture, art and design are also inspired by nature (TEEB, 2011).

2.4.4 Spiritual Experience and Sense of Place

Geographical features like certain forests and mountains in many parts of the world are believed to have a sacred or religious meaning. Nature is a common element that constitutes all major religions and traditional knowledge, and customs related to nature are important to form a belonging sense.

For example, in the Maron Church located in Lebanon, due to that the hills of Mediterranean forests are closely related to Marron culture, theology and religion, they are strived to be protected as their property (Palmer&Finlay, 2003).

Chapter 3. Methodology

3.1 The Delphi Analysis

The Delphi method is a popular tool for modern foresight in many countries (Ronde, 2003). It was developed by employees of the Rand Corporation in the 1950s. Since that time, it has become a widely-used evaluation research technique. It suggests that we can acquire a tool for measuring and aiding forecasting without extensive knowledge of the potential benefits of decision making in different disciplines (Rowe, 1999).

Table 7 Procedure for selecting experts in the example study

Step 1: Prepare KRNW	1. Identify relevant disciplines or skills: academics, practitioners, government officials, and officials of NGOs 2. Identify relevant organizations 3. Identify relevant academic and practitioner literature
Step 2: Populate KRNW with names	1. Write in names of individuals in relevant disciplines or skills 2. Write in names of individuals in relevant organizations 3. Write in names of individuals from academic and practitioner literature
Step 3: Nominate	1. Contact experts listed in KRNW 2. Ask contacts to nominate other experts

additional experts	
Step 4: Rank experts	1. Create four sub-lists, one for each discipline 2. Categorize experts according to appropriate list 3. Rank experts within each list based on their qualifications
Step 5: Invite experts	1. Invite experts for each panel, with the panels corresponding to each discipline 2. Invite experts in the order of their ranking within their discipline sublist 3. Target size is 10-18 4. Stop soliciting experts when each panel size is reached

[Source: Okoli, 2004 (Knowledge Resource Nomination Worksheet --- KRNW)]

The explanations of urban forest ESs were shown to experts and the first online questionnaire survey was conducted with experts to investigate preferences and the importance of the 18 types of ESs based on the literature review.

The experts recruited were those in forestry, landscape architecture, and urban planning. There were also public officials employed by the Beijing Gardening and Greening Bureau along with the Beijing Urban Planning Bureau. They were contacted via email and Wenjuanxing, an online professional survey, evaluation and polling platform. There was a total of 30 experts, and effective responses were received.

There are two distinct relationships between ecosystem services: trade-off and companion. A trade-off relationship means that one

ecosystem service's function increases while other ecosystem service's function decreases. A companion relationship means that as one ecosystem service's function increases, another ecosystem service's function also increases. Please consider these when answering the survey questions. (1—important; 2—medium; 3—unimportant.)

According to "Importance Value =#A*3+#B*2+#C*1", the results are as follows:

Table 8 Importance value of ESs

ES	Rank the importance			Importance Value (#A*3+#B*2+#C*1=)
	1st	2nd	3rd	
1.Food	11	7	12	59
2.Raw materials	5	6	19	46
3.Fresh water	22	8	0	82
4.Medicinal resources	8	8	13	56
5.Local climate and air quality regulation	30	0	0	90
6.Carbon sequestration and storage	18	12	0	78
7.Moderation of extreme events	22	8	0	82
8.Waste-water treatment	12	16	2	70
9.Erosion prevention and maintenance of soil fertility	21	8	1	80
10.Pollination	8	19	3	65
11.Biological control	19	10	1	78

12. Noise reduction	21	9	0	81
13.Habitats for species	20	9	1	79
14. Maintenance of genetic diversity	16	12	2	74
15. Recreation and mental and physical health	24	6	0	84
16.Tourism	18	12	0	78
17.Aesthetic appreciation and inspiration for culture, art and design	22	7	1	81
18.Spiritual experience and sense of place	23	7	0	83

According to above result, the important rank is as follows.

Table 9 Importance value rank of ESs

1	**5.local climate and air quality regulation**	90
2	**15.Recreation and mental and physical health**	84
3	**18.Spiritual experience and sense of place**	83
4	**7.mederation of extreme events**	82
5	**3.fresh water**	82
6	**17.Aesthetic appreciation and inspiration for culture, art and design**	81
7	**12.Noise reduction**	81
8	**9.Erosion prevention and maintenance of soil**	80

	fertility	
9	**13.Habitats for species**	79
10	**6.carbon sequestration and storage**	78
11	**16.Tourism**	78
12	**11.Biological control**	78
13	**14.Maintenance of genetic diversity**	74
14	**8.waste-water treatment**	70
15	**10.Pollination**	65
16	**1.Food**	59
17	**4.medicinal resources**	56
18	**2.raw materials**	46

The first conclusive experts' responses were again sent to the same 30 experts. They were asked if they would change their responses after viewing their initial results. The second round of results concluded with 30 effective responses.

Table 10 The second survey results

1	**5.Local climate and air quality regulation**	90
2	**6.Carbon sequestration and storage**	86
3	**15.Recreation and mental and physical health**	74
4	**3.Fresh water**	72
5	**12. Noise reduction**	72

6	**7.Moderation of extreme events**	69
7	**18.Spiritual experience and sense of place**	69
8	**9.Erosion prevention and maintenance of soil fertility**	67
9	**17.Aesthetic appreciation and inspiration for culture, art and design**	65
10	**14.Maintenance of genetic diversity**	62
11	**16.Tourism**	58
12	**13.Habitats for species**	57
13	**11.Biological control**	52
14	**8.Waste-water treatment**	42
15	**10.Pollination**	38
16	**1.Food**	36
17	**4.Medicinal resources**	35
18	**2.Raw materials**	33

The next section presents an analysis of the first and second surveys' results.

Table 11 Comparison of the first and second survey results by Delphi analysis

1	**Local climate and air quality regulation**	Didn't change
2	**Carbon sequestration and storage**	From 10 up to 2
3	**Recreation and mental and**	From 2 up to 3

	physical health	
4	**Fresh water**	From 5 down to 4
5	**Noise reduction**	From 7 up to 5
6	**Moderation of extreme events**	From 4 down to 6
7	**Spiritual experience and sense of place**	From 3 down to 7
8	**Erosion prevention and maintenance of soil fertility**	Didn't change
9	**Aesthetic appreciation and inspiration for culture, art and design**	From 6 down to 9
10	**Maintenance of genetic diversity**	From 13 up to 10
11	**Tourism**	Didn't change
12	**Habitats for species**	From 9 down to 12
13	**Biological control**	From 12 down to 13
14	**Waste-water treatment**	Didn't change
15	**Pollination**	Didn't change
16	**Food**	Didn't change
17	**Medicinal resources**	Didn't change
18	**Raw materials**	Didn't change

The 5 lowest-ranking ES types (Wastewater Treatment, Pollination, Food, Medicinal resources, and Raw Materials) were removed from consideration due to their relatively low importance value, leaving 13ES types remaining.

3.2 Regrouping 13 ESs into 6 Groups

The second survey regrouped the 13 types of ESs into 6 groups. This method involved conducting a survey about the respondents' opinions regarding the relationship between 2 different ecosystem services. In this case, 1-5 represented the relationship between 2 ecosystem services (1.Very closely related, 2. Closely related, 3. Neutral, 4. Not closely related, 5. Unrelated).

The result was that 30 experts were surveyed regarding the regrouped 13 ESs. There were 22 effective responses.

In this case, smaller numbers meant a closer relationship. In addition, it is more likely that the ESs sharing close relationships could be combined to form a single group. The closely related ESs were then regrouped based on mutual relationships.

Table 12 The result of relationship between 2 ecosystem services

	1	2	3	4	5	6	7	8	9	10	11	12	13
1													
2	39												
3	58	31											
4	44	80	84										
5	42	68	78	54									
6	62	33	33	75	72								
7	81	54	63	69	94	62							
8	57	80	85	42	53	82	94						
9	37	71	69	50	38	73	72	47					
10	40	69	83	59	63	86	91	54	65				
11	45	27	39	56	52	29	50	66	49	79			
12	47	72	77	52	52	75	76	58	44	62	69		
13	45	77	75	52	49	72	80	54	29	58	66	36	

Table 13 The result of regrouping 13 ESs into 6 groups

1.local climate and air quality regulation	Regroup	1. Fresh water provision
2.Recreation and mental and physical health		
3.Spiritual experience and sense of place		2. Noise reduction
4.moderation of extreme events		
5.fresh water provision		3. Water/soil conservation (including extreme events)
6.Aesthetic appreciation and inspiration for		

culture, art and design		
7.Noise reduction		4. Climate and air quality regulation (including climate change mitigation)
8.Erosion prevention and maintenance of soil fertility		
9.Habitats for species		5. Biodiversity conservation
10.carbon sequestration and storage		
11.Tourism		6. Cultural service (including recreation, tourism, aesthetic appreciation, spiritual experience)
12.Biological control		
13.Maintenance of genetic diversity		

3.3 Choice Experiment (CE)

The literature review indicated that there are some urban forest ES attributes and attribute levels. The third survey focused on 30 experts and helped define the correct ES attributes and attribute levels. It resulted in 30 effective responses. This is described below.

Table 14 The results of defining the urban forest ES attributes and attribute levels

Q1	1	2
Expert	30	0
Percentage	100%	0
Q2	1	2
Expert	22	8
Percentage	73.3%	26.7%
Q3	1	2
Expert	9	21
Percentage	30%	70%
Q4	1	2
Expert	20	10

Percentage	66.7%	33.3%
Q5	1	2
Expert	32	0
Percentage	100%	0
Q6	1	2
Expert	24	6
Percentage	80%	20%

Based on the results of the red-colored section, the attribute, indicator and attribute level were defined.

Table 15 The attribute, indicator and attribute level for ES

Ecosystem service	Attribute	Indicator	Attribute level
1. Fresh water provision	Fresh water provision	Proportion of broadleaf trees	The ES of fresh water provision is low, if it only has softwood.
			The ES of fresh water provision is high, if it only has hardwood.
2. Noise reduction	Noise reduction	Floral composition	The ES of noise reduction is low, if only trees were present.
			The ES of noise reduction is high, if trees and shrubs were present.
3. Soil conservation (including moderation of extreme events)	Moderation of extreme events (landslide)	Coverage of low-lying vegetation	The prevention of soil loss and landslides is low, if the coverage of low-lying vegetation is below 30%.
			The prevention of soil loss and landslides is high, if the coverage of low-lying vegetation is above 70%.
4. Climate and air quality regulation	Air Quality Regulation	Tree crown coverage	The ES of air quality regulation is low, if tree crown coverage is below 25%.

(including climate change mitigation)			The ES of air quality regulation is middle, if tree crown coverage is 25-75%.
			The ES of air quality regulation is high, if tree crown coverage is above 75%.
5. Biodiversity conservation	Species diversity and wildlife habitat	The number of plant species /km^2	The species diversity and wildlife habitat is low, if the forest is composed of a single species of tree.
			The species diversity and wildlife habitat is rich, if the forest is composed of multiple species of tree and shrubs.
6. Cultural service (including recreation, tourism, aesthetic appreciation and spiritual experience)	Recreation and Spiritual Experience	Density of trails	The ES of recreation and therapy service is low, if density of trails is low.
			The ES of recreation and therapy service is medium, if density of trails is medium.
			The ES of recreation and therapy service is high, if density of trails is high.
7. Willingness-to-pay	Municipality Tax	Level of payment	4300WON (25RMB), 8600WON(50RMB), 12900WON(75RMB).

3.4 Experimental Design

A total of 576 combinations can be created with 4 attributes with 2 levels, 2 attributes with 3 levels, and 1 attribute with 4 levels of urban forest ecosystem services. It is unfeasible to develop a questionnaire containing all of these combinations, so the number of alternatives was reduced by using an SPSS orthogonal design procedure. The SPSS procedure produced 16 alternatives (Table 16) for the pilot survey and main survey. The 16 alternatives were also randomly divided into 8

different versions, each with 2 choice sets. This was to further simplify the survey format. A choice set consisted of 2 management scenario profiles and an option to select neither scenario. Each interviewer was asked to choose a set four times. Table 17 shows an example of a questionnaire with this choice set.

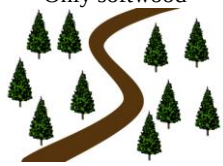
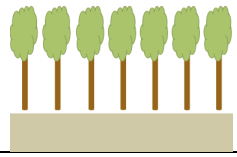
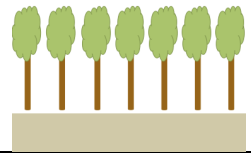
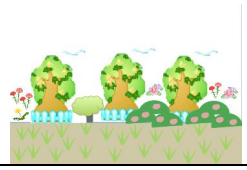
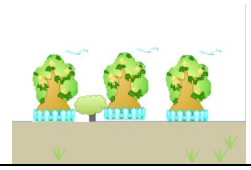
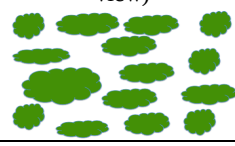
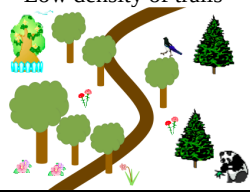
Table 16 Card List of 16 alternatives of urban forest ecosystem services

Card ID	Fresh_water_provision	Noise_reduction	Moderation_of_extreme_events	Air_quality_regulation	Species_diversity_and_wildlife_habitat	recreation_and_spiritual_experience	Municipality_tax
1	only softwood	trees and shrubs	low-lying vegetation below 30%	tree crown coverage 25%-75%	plant species ranges 197-590	low density of trails	50RMB
2	only softwood	trees and shrubs	low-lying vegetation above 70%	tree crown coverage below 25%	plant species ranges 197-590	high density of trails	200RMB
3	only hardwood	trees and shrubs	low-lying vegetation above 70%	tree crown coverage below 25%	plant species ranges 197-590	medium density of trails	50RMB
4	only softwood	trees and shrubs	low-lying vegetation above 70%	tree crown coverage above 75%	plant species ranges above 590	low density of trails	100RMB
5	only hardwood	only trees	low-lying vegetation below 30%	tree crown coverage below 25%	plant species ranges 197-590	low density of trails	25RMB
6	only hardwood	trees and shrubs	low-lying vegetation below 30%	tree crown coverage above 75%	plant species ranges 197-590	low density of trails	200RMB

7	only softwood	trees and shrubs	low-lying vegetation below 30%	tree crown coverage below 25%	plant species ranges above 590	high density of trails	25RMB
8	only hardwood	only trees	low-lying vegetation above 70%	tree crown coverage 25%-75%	plant species ranges 197-590	high density of trails	100RMB
9	only hardwood	trees and shrubs	low-lying vegetation below 30%	tree crown coverage below 25%	plant species ranges above 590	medium density of trails	100RMB
10	only softwood	only trees	low-lying vegetation below 30%	tree crown coverage below 25%	plant species ranges 197-590	low density of trails	100RMB
11	only softwood	only trees	low-lying vegetation below 30%	tree crown coverage 25%-75%	plant species ranges above 590	medium density of trails	200RMB
12	only softwood	only trees	low-lying vegetation above 70%	tree crown coverage above 75%	plant species ranges 197-590	medium density of trails	25RMB
13	only hardwood	trees and shrubs	low-lying vegetation above 70%	tree crown coverage 25%-75%	plant species ranges above 590	low density of trails	25RMB
14	only softwood	only trees	low-lying vegetation above 70%	tree crown coverage below 25%	plant species ranges above 590	low density of trails	50RMB
15	only hardwood	only trees	low-lying vegetation above 70%	tree crown coverage below 25%	plant species ranges above 590	low density of trails	200RMB
16	only hardwood	only trees	low-lying vegetation below 30%	tree crown coverage above 75%	plant species ranges above 590	high density of trails	50RMB

Table 17 Example of questionnaire with the choice set

Which of the following urban forest ecosystem services do you favor? Option A and

option B would entail a cost to your household. No payment would be required for "Neither A nor B" option.			
	Scenario A (Card 14)	Scenario B (Card 16)	
Fresh water provision	Only softwood 	Only hardwood 	
Noise reduction	Only trees 	Only trees 	
Moderation of extreme events (landslide)	Low-lying vegetation above 70% 	Low-lying vegetation below 30% 	Neither A nor B: I prefer NO urban forest ecosystem services change
Air quality regulation	Tree crown coverage below 25% (vertical view) 	Tree crown coverage above 75% (vertical view) 	
Species diversity and wildlife habitat	Plant species ranges above 590 	Plant species ranges above 590 	
Recreation and spiritual experience	Low density of trails 	High density of trails 	
Municipality tax	50RMB	50RMB	
I would prefer:	Choice A ○	Choice B ○	Neither ○

The questionnaire was comprised of 4 parts.

Table 18 Structure of the questionnaire

Part	Contents
A	The first part was attitudinal questions (Table 6). These included the frequency of visits, visiting motives, the usages and the perception of urban forests, and the likeability of Beijing.
B	The second part included descriptions of the attributes of the choice experiment. This consisted of questions regarding the importance of 6 types of urban forest ecosystem services.
C	The third part was a choice experiment --- 4 choice sets (questions), each with 2 alternatives and 1 optional alternative.
D	The forth part considered socio-economic data (Table 7). This focused on questions about age, gender, marriage, number of children under 20 years old, education level, employment, if the job is environment- or forest-related, income level, if the respondent has a history of living in a rural area, the number of years spent living in the countryside, and if they have an apartment in Beijing.

3.5 Data collection

Beijing has a total population of 21.729 million as of 2016. The urban population of Beijing was 18.796 million in 2016 (Beijing Statistical Information Net). With a margin of error set to 4%-5% at a 95% confidence level, a sample size consisting of 384 to 600 people was deemed to be the most appropriate. In total, there were 560 questionnaires, 8 versions, including 16 districts, according to census information. There

were 56 respondents who expressed a very poor or poor ability in understanding the information provided in the questionnaire. In addition, 21 questionnaires were incomplete. As a result, 77 invalid questionnaires were removed from the analysis, leaving a total of 483 valid questionnaires for analysis. Table 19 shows that the valid sample can almost confirm the principle of the population density ratio. It also is an accurate indication as to the entire population of Beijing.

Table 19 Population of region sample

	Region	Population (ten thousand) (Census)	Population of sample (In total: 560)	Population of valid sample (In total: 483)
1	Dongcheng district	34.6	36	32
2	Xicheng district	48.5	51	42
3	Chaoyang district	81.0	86	68
4	Fengtai district	47.0	50	39
5	Shijingshan district	14.7	16	14
6	Haidian district	72.4	77	77
7	Shunyi district	27.0	29	24
8	Tongzhou district	35.4	37	31
9	Daxing district	26.9	28	26
10	Fangshan district	37.8	40	38
11	Mentougou district	12.1	13	13
12	Changping district	26.6	28	26
13	Pinggu district	17.0	18	13
14	Miyun district	20.7	22	14

15	Huairou district	13.6	14	13
16	Yanqing district	14.0	15	13

There were a total of 4 surveys conducted. Table 20 shows response-related statistics. From the 27th of October to the 4th of November, the final survey (field survey) was conducted. This examined 560 Beijing citizens who were aged 20 or more than 20 years old, had visited any one of Beijing's 50 urban country parks, 46 urban parks, 20 nature reserves and 24 forest parks during 2016, or had lived in Beijing for 1 year or more than 1 year.

Table 20 Response statistics

Survey		Case number (people)	Valid response number	Response Proportion (%)
The first online experts survey (Delphi analysis)	First	30	30	100
	Second	30	30	100
The second online experts survey for regrouping ESs		30	22	73.3
The third online experts survey for defining the urban forest ES attributes and attribute levels		30	30	100
The final field survey in Beijing		560	483	86

3.6 Model estimation (Conditional Logit model)

(Equation 1) is based on McFadden (1973)'s Random utility model

$$U_{nj} = V_{nj} + e_{n1} \quad (1)$$

When the subject (n) chooses the alternative (j), Indirect utility function U_{n1} is formed with the fixed part V_{n1} and probability part e_{n1}. Following the demand characteristics theory (Lancaster, 1957), the fixed V_{n1} is formed with (n) number of attributive vectors.

(Equation 2) is comprised of the linear of sum of the number of n attribute's vector.

$$V_{ni} = \sum_{k=1}^{m} \beta_k X_i \quad (2)$$

X_1, (Equation 3) shows the probability for (n) number of respondents to select j instead of i based on the Discrete Choice model (Hanemann, 1984).

$$P_{ni} = \Pr(V_{nj} + e_{nj} > V_{\ni} + e_{\ni}) \quad (3)$$

In Conditional Logit model (Boskin, 1974), the parameter value was estimated assuming the probability part based on Gumble distribution/Extreme value type I distribution shown in (Equation 1).

The probability distribution is shown in (Equation 4).

$$P_{nj} = \frac{e^{\beta' xni}}{\sum_i e^{\beta' xni}} \quad (4)$$

Chapter 4. Results and discussion

4.1 Citizens' Preferences for Forest Ecosystem Services

Here are the results of the surveys. Table 21 shows the respondents' socio-demographic characteristics, and details of each part are provided in Table 22.

Table 21 Description of the sample

	N	Minimum	Maximum	Mean	Std. Deviation
Gender[a]	483	0.00	1.00	0.48	0.50
Age	483	20.00	84.00	40.52	14.71
Education Level[b]	483	1.00	5.00	3.68	0.90
Monthly Household Income[c]	483	1.00	8.00	3.35	1.29
Years Lived in Countryside[d]	483	0.00	3.00	1.39	1.33
Apartment Owner	483	0.00	1.00	0.43	0.50
Relative Environmental Work	483	0.00	1.00	0.12	0.33

[a] Male = 0; Female = 1
[b] Elementary school graduate = 1; Middle school graduate = 2; High school graduate = 3; University degree holder = 4; Graduate school student / Graduate degree holder = 5
[c] Below 5000 (RMB) = 1; 5000~9999 (RMB) = 2; 10000~14999 (RMB) = 3; 15000~19999 (RMB) = 4; 20000~24999 (RMB) = 5; 25000~29999 (RMB) = 6; 30000~34999 (RMB) = 7; Over 35000 (RMB) = 8
[d] 0 year = 0; Below 1 year (remove 0) = 1; 1-3 years = 2; Above 3 years = 3
e Non-apartment owner = 0; Apartment Owner = 1
[f] Irrelative Environmental Work = 0; Relative Environmental Work = 1

The results related to statistics for respondents' socio-demographic characteristics reveal specific information regarding the respondents. Their gender mean is 0.48, meaning that the gender ratio is almost balanced. Their ages range from 20 to 84 years old. Their education level mean is 3.68, meaning that it is centered on a level between a high school diploma holder and someone with an university degree. Their monthly household income mean is 3.35, indicating that the respondents' monthly household income is almost 14,316 RMB. The mean for years lived in the countryside is 1.39, which indicates that most of them had lived in the countryside for about 1 year. The mean for apartment owners is 0.43, meaning that 43.5% of respondents do not own one located in Beijing. The respondents' jobs were seldom related to the environment or a forest.

Table 22 Descriptive statistics of respondents' characteristics

Characteristics	Sample N=483	Proportion of population (%) (Census)

Gender		
Male	51.6	51.3
Female	48.4	48.7
Age		
20-29	29.4	24.6
30-39	25.0	21.8
40-49	17.3	18.6
50-59	14.3	17.0
60 and above	13.9	18.0
Monthly household income		
Below 5000 (RMB)	5.0	
5000~9999 (RMB)	23.2	
10000~14999 (RMB)	28.4	
15000~19999 (RMB)	24.8	
20000~24999 (RMB)	14.9	
25000~29999 (RMB)	1.9	
30000~34999 (RMB)	1.2	
Over 35000 (RMB)	0.6	
Apartment owner		
Yes	56.5	
No	43.5	
Marriage		
Married	69.2	
Single	30.8	
Number of children (under 20 years old)		
None	65.2	
1	31.7	
2	3.1	
3 and above	0	
Education level		
Elementary school graduate	0.8	
Middle school graduate	7.9	
High school graduate	32.7	
University degree holder	39.3	
Graduate school student or Graduate degree holder	19.3	
Work related to environment or forest		
Yes	87.6	
No	12.4	
Emotionally connected to Beijing		
Much less deep	4.4	

Less deep	13.7	
Middle	20.9	
More deep	27.7	
Much more deep	33.3	

The results of the statistics for respondents' characteristics in Table 22 show that 69.2% of respondents were married and 30.8% of respondents were single, 65.2% of respondents did not have children under 20 years old, and 31.7% of respondents had one child under 20 years old. It also indicated that 18.1% of them did not like Beijing, while 61% of respondents felt emotionally connected to their city.

Table 23 uses the STATA conditional logit model to estimate the empirical model results of the base model (without considering socioeconomic interactions) are specified in equation (3). Dummy coding was used to code all of the qualitative variables. The coefficient is the estimated parameter used to calculate the utility provided by the change in the given attribute. The coefficient indicates the direction of movement of the utility derived from an increase in the level of the attribute. A larger coefficient means that it will have a stronger effect on the probability of citizens preferring an ES choice. That is to say, a positive coefficient indicates that an increase in the attribute level will increase the utility provided. On the contrary, a negative coefficient shows that an increase in the attribute level will decrease the utility provided with all other conditions remaining constant. The standard error (SE) is a measure of how accurately a sample represents a population. sampling distribution.

The P-value indicates the risk level at which the null hypothesis can be rejected. The R2 shows how much of the choice behavior the model can explain. Pseudo R2 helps to understand whether R2 makes sense. An example of this is to suppose that the covariates in the current model do not actually provide any predictive information regarding the outcome.

Table 23 Estimated conditional logit model

Choice		Coef.	Std.Err.	P>|z|
FWProvision (base= low)	high	.8628245	.088115	0.000
Nreduction (base= low)	high	.1832588**	.0983115	0.062
EEModeration (base= low)	high	-.1651776	.0793189	0.037
AQRegulation (base= low)	middle	.5644519**	.0966763	0.000
	high	1.742907***	.1130131	0.000
Species (base= low)	high	-.1216553	.0873506	0.164
RecreationandSE (base=low)	medium	.6192334**	.1036891	0.000
	high	-.2001552	.100378	0.046
MunicipalityTax		.0066003	.0006256	0.000
No. of Observation	3864			
Pseudo R2	0.2743			
Log likelihood	-931.59757			
Significant levels: * 10%, ** 5%, ***1%				

Positive coefficients were obtained for the municipality tax. The estimated coefficients unite with the municipality tax to demonstrate the positively related relationship between the municipality tax and preference for an alternative. That is to say, the respondents preferred the highest tax alternative, which is different from the preference for a lower tax alternative in general. There is one explanation that respondents' answers

reflected a very low level for the tax options. This is that this kind of tax would not be particularly high. Another explanation is that Beijing citizens are particularly willing to pay to change the current ESs. This means that the current environmental situation increases Beijing citizens' awareness of the importance of environmental protection.

The conditional logit model does not account for preference heterogeneity, meaning individuals do not express their own identical preferences when choosing alternatives between choice cards. Table 24 shows that Beijing citizens are most willing to pay to ensure stricter air quality regulations and have the city provide more ESs. This may be since Beijing citizens are tired of suffering from a severe haze problem. A statement on the first hypothesis is coincident here. The second observation in Table 24 is that in terms of fresh water, it seems that Beijing citizens pay little attention to the moderation of extreme weather occurrences such as landslides. This may be since Beijing has been facing a water shortage due to the pressures of its large population, while landslides rarely occur in Beijing. It is interesting to note that citizens are willing to pay a moderate amount for recreation and spiritual experiences while not showing interest in paying a large amount for these same aspects. This may be due to their belief that paying a moderate amount is sufficient and it is foolish to spend excessively on activities related to recreation or spiritual experiences.

Table 24 Calculated willingness-to-pay (WTP) for municipality tax for various ESs

		Mean WTP	95% CI	
			Minimum	Maximum
FWProvision (base= low)	high	130.72487	97.397046	164.05269
Nreduction (base= low)	high	27.76519	- .98703583	56.517416
EEModeration (base= low)	high	- 25.025741	- 47.565532	- 2.48595
AQRegulation (base= low)	middle	85.519017	52.996155	118.04188
	high	264.06453	207.93186	320.19719
Species (base= low)	high	-18.431756	- 43.644341	6.7808295
RecreationandSE (base=low)	medium	93.818855	58.806357	128.83135
	high	- 30.325132	- 59.050255	- 1.6000096

4.2 Comparing Different Respondent Groups

4.2.1 Apartment Owners and Non-apartment Owners

There were 483 respondents included in this analysis. Two models are estimated here, considering Model (1), or respondents who self-identified as apartment owners and Model (2), or respondents who self-identified as non-apartment owners. The level of willingness to pay a municipality tax per year for each attribute is described in Table 25.

Table 25 Comparison of WTP values for apartment owner and non-apartment owner

Attributes		Model (1) Apartment owner		Model(2) Non-apartment owner	
		Mean WTP	Coef.	Mean WTP	Coef.
MunicipalityTax		-	.021859	-	.0023718
FWProvision (base= low)	high	319.87528	1.76516***	80.752198	.7586834**
Nreduction (base= low)	high	10.52408	.9134958**	41.790426	.0249611
EEModeration (base= low)	high	-167.26169	-.3436072	-15.719276	-.3967129
AQRegulation (base= low)	middle	161.25559	1.554199***	71.101193	.3824676*
	high	679.67622	3.561241***	162.91894	1.612063***
Species (base= low)	high	134.0457	-1.57058	-71.850595	.3179309*
RecreationandSE (base=low)	medium	291.7614	.2998301*	13.716567	.6920026**
	high	-19.914824	-1.046033	-47.853697	-.0472342
Significant levels: * 10%, ** 5%, ***1%					

Apartment owners expressed a high level of willingness to pay for the fresh water, air quality regulation, species diversity and wildlife habitat ESs. They expressed a middle level of willingness regarding the recreation and spiritual experience ESs in comparison with non-apartment owners. If apartment owners are highly correlated to income level, this result could also be attributed to higher income levels. Non-apartment owners are more willing to pay for the noise reduction ES in comparison

with apartment owners. This may be since non-apartment owners live in a rented room with poor insulation. Regardless of the individual, they are all unwilling to pay a moderate amount for the extreme events ES and a high amount for the recreation and spiritual experience ES. In the case of the recreation and spiritual experience ES, it shows that citizens have no particularly high demand for recreation and spiritual experiences, while a middle level of spending on the recreation and spiritual experience ES is enough.

The results of this study show that apartment owners are remarkably and positively related to a willingness to pay. There may be two reasons for this phenomenon. One is that non-apartment owners will not stay in Beijing for a long time, so they are not very concerned about the development of an ecological environment in Beijing. Another possibility is that non-apartment owners are usually low-income and unwilling to pay. The non-apartment owners' coefficient is positive. This may be that since the municipality tax is low, they can afford it. Another explanation is that Beijing's environmental problems are very serious, and as a result, citizens want to improve this situation despite their poverty.

4.2.2 Different Household Income Levels

This section analyzed 483 respondents. Four models are estimated, in which Model (3) to Model (6)'s respondents represent different household income levels (Table 26).

Table 26 Comparison of WTP values for different household income level

Attributes		Model (3) Income below 10000 RMB	Model (4) Income 10000-14999 RMB	Model (5) Income 15000-19999 RMB	Model (6) Income over 19999 RMB
		Coef.	Coef.	Coef.	Coef.
Municipality Tax		-.0006508	.0070727	.0131855	.026987
FWProvision (base= low)	high	.9967295*	.852**	.959**	2.27***
Nreduction (base= low)	high	-.3989304	.1636622	.654521**	.867**
EEModeration (base= low)	high	-1.118169	-.1433766	-.0645278	-.0390879
AQRegulation (base= low)	middle	-.314992	.755**	1.30***	2.11***
	high	1.645***	1.52***	2.67***	4.457***
Species (base= low)	high	.9336587	-.0350271	-.5782473	-2.533598
RecreationandSE (base=low)	medium	1.42703	.41*	-.1307427	.3581*
	high	.1731052	-.4357673	-.8046564	-1.037029
Significant levels: * 10%, ** 5%, ***1%					

Citizens with high household income are positively related to a willingness to pay the tax for receiving urban forest ESs. The

low household income citizens' coefficient is minus. It indicates that low household income citizens have a negative impact on one's willingness to pay a municipality tax. However, low-income citizens are still willing to pay for the fresh water and air quality regulation ESs.

4.2.3 Emotional Connection to Beijing

There are 3 models considered in this analysis: Model (9) for respondents who are emotionally connected to Beijing, Model (8) for middle and Model (7) for less deep of a connection. The willingness to pay a municipality tax each year for each attribute are as follows (Table 27).

Table 27 Comparison of WTP values for emotionally connected to Beijing

Attributes		Model (7) Much less deep and less deep		Model(8) Middle		Model(9) More deep and much more deep	
		Mean WTP	Coef.	Mean WTP	Coef.	Mean WTP	Coef.
MunicipalityTax		----	-.0085371	----	.0054177	----	.0131855
FWProvision (base=low)	high	124.90	1.0662*	178.06	.96469*	104.52	.8855827**
Nreduction (base=low)	high	6.88	-.05878	23.41	.12684	27.58	.23369

EEModeration (base=low)	high	9.69	-.08269	-62.38	-.33795	-4.53	-.03840
AQRegulation (base=low)	middle	-34.25	.29242	49.04	.26569	80.22	.67974
	high	180.44	1.5404***	241.38	1.3077***	231.92	1.9650***
Species (base=low)	high	114.3	.97621	.46	.0025083	-33.93	-.28747
RecreationandSE (base=low)	medium	-151.27	1.2914	212.67	1.1521	40.93	.34683
	high	-115.42	.98535	14.28	.07737	-54.90	-.46513
Significant levels: * 10%, ** 5%, ***1%							

Citizens who are emotionally connected to Beijing are positively related to a willingness to pay for urban forest ESs. Citizens with a less deep emotional connection to Beijing have a coefficient that is minus. This indicates that citizens with less deep of an emotional connection to Beijing negatively impact their willingness to pay a municipality tax. However, regardless of who has less deep of an emotional connection to Beijing, they are still willing to pay for the fresh water and air quality regulation ESs.

Chapter 5. Conclusion

The results are as follows: Firstly, the air quality regulation ES is considered as the most influential service for Beijing citizens in terms of their choice of urban forest management strategies. Beijing citizens were willing to pay 85 RMB per year for urban forests capacity of air quality regulation from low to middle level, while 264 RMB per year for the improvement from middle to high level. In addition, Beijing citizens regarded the fresh water ES as the second-most important ES. Secondly, citizens with a high monthly household income are more willing to pay. Thirdly, apartment owners are positively related to a willingness to pay the municipality tax compared to non-apartment owners. Fourthly, citizens emotionally connected to Beijing have a positive impact on a willingness to pay a municipality tax. The results indicate that citizens are willing to pay a tax that can support urban forestry for air quality improvement. This research suggests for urban environmental policy makers in Beijing to pay more attention to air quality regulation function of forests. It is also recommended to design and manage urban forests to satisfy its visitors.

Beijing citizens are the most willing to pay a tax for high air quality regulation ESs of urban forests, at 264RMB/year. Beijing citizens regard air quality improvement as the most important ES of urban forets

when choosing between two options for urban forests management. This confirms Hypothesis 2. Apartment owners, a high household income, and an emotional connection to Beijing are respectively and positively related to a willingness to pay a tax to receive urban forest ESs. This also confirms Hypothesis 1, 3 and 4. Beijing citizens are becoming increasingly interested in environmental protection. In the future, the government should develop more urban environmental policies related to air quality improvements especially taking into account of forest carbon sequestration function. In this way, the general public and governmental agencies can cooperate to promote environmental protection. Beijing citizens have a well-developed sense of environmental awareness. This means that there is potential for them to support environmental protection taxes. This can help them realize that the urban forest can provide them with ecosystem services. Improving their sense of belonging may also improve citizens' attitude towards embracing ES

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List of Appendices

APPENDIX A First online experts survey

Expert questionnaire survey for investigating preference and importance of urban forest ecosystem service

Hello! I am Han Zhiying, a student taking master courses from ecological economics laboratory in the department of forest sciences, Seoul National University.

This questionnaire survey is made for clarifying different preference of urban residents for ecosystem service of different types of urban forest (urban parks in downtown area, including Summer Palace, Temple of heaven park, Beihai park and etc., and urban country parks in suburb area, including Xinglong park, Guta park, Jiangfu park and etc.), and collecting opinions of experts in the field for providing the basis when making urban forest strategies for improving the convenience of the urban residents.

This questionnaire survey is aim at regrouping the present ecosystem service from which is made up of respective 4 primary types and 17 secondary types into similar 6 to 8 types of services, for creating proper number of groups when conducting the questionnaire survey and taking the urban residents as the object. It should be noted that after conducting questionnaire survey 2 or 3 times approximately, illustrated grouping contents could be removed, and other contents could be added on the basis of opinions of the experts. And the result of former questionnaire survey would be provided in the later questionnaire survey for inducing collection of experts' opinions. Meanwhile, this questionnaire survey is voluntary and any information of the participants would not be disclosed.

The questionnaire in the below, which is carried out in Delphi method of the first survey, is about the classification factors of ecosystem service in present literatures without considering their respective significance. Firstly, please regroup the ecosystem service from 17 types into 6 to 8 types and explain the reason, referring to illustrated specific contents of ecosystem service. Secondly, please select one among the 6 to 8 types of ecosystem service, which can bring in best improvement effect through forest enterprise. Thirdly, please describe the most adequate management method in your opinion for improving the selected ecosystem service.

Thank you for taking your time conducting this questionnaire survey. Wish you health and prosperity.

Ecological Economics Laboratory, Seoul National University
Han Zhiying

※ If you have any other questions, please do not hesitate to contact the author.

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※ Before answer the survey questionnaire, please read the introduction of urban forest and ecosystem service.

▷ The urban forest, which includes vegetation along urban streets and in urban parks, woodlots, abandoned sites, and residential areas, can constitute an important percent of a nation's tree cover.

'Urban forest' and 'Urban trees' and 'Urban green space'

◆ Urban forest: Forest or trees planted and managed in urban area for health, rest, entertainment and emotion regulation of the residents (Except remote area). In addition, it is the general term of the urban green space with the forest as the main body.

◆ Urban green space： In China, it is divide into 5 parts, including urban park green space, production green space, protection green space, attached green space and other green space.

◆ Residential forest: Forest or trees planted and managed in residence, school and surrounding area for supplying well-being life environment, beautiful view and study of nature for the residents (School forest, Garden forest, Landscape forest).

◆ Roadside trees: Trees in the roadside or surrounding areas. (Roadside forest: Group of roadside trees, and forest planted and managed in the space of roadside or surrounding area.)

◆ Urban forest and so forth: Urban forest + Residential forest + Roadside trees + other

◆ Urban forest: Narrow sense of 'Urban forest' and broad sense of 'Urban forest and so forth'

▹ Ecosystem services can be divided into four categories: provisioning services, regulating services, habitat (or supporting) services, and cultural services. There are 18 types of individual ESs relevant to cities (TEEB, 2011; Aylor, 1979; Morar, 2014).

1, 2, 3, respectively, represent the importance degree of urban forest ecosystem services for Beijing citizens, 1 - important, 2 - medium, 3 - unimportant. Please in the 18 types of ecosystem services mark 1, 2, 3 levels.

Ecosystem service	Illustration for the service		Mark
I. Provisioning services: ecosystem services of material and energetic supply from ecosystem.			
1.Food		Urban forest ecosystems provide conditions for growth of food resource. Food resource is obtained from agriculture ecosystem and forest.	
2.Raw materials		Urban forest ecosystems supply various raw materials and fuels for construction.	
3.Fresh water		Urban forest ecosystems play an important role in the supply of drinking water.	
4.Medicinal resources		Urban forest ecosystems can provide raw material of traditional medicine.	
II. Regulating services: The services of regulating the quality of air and soil and preventing natural disasters and diseases, etc.			
5.Local climate and air quality regulation		Urban forests can influence on the climate and air quality.	
6.Carbon sequestration and storage		Growth of trees and plants can decrease the level of carbon dioxide in the atmosphere effectively.	
7.Moderation of extreme events		Organisms in the urban forest ecosystems can create cushion for the natural disasters and reduce the loss caused by the extreme weathers and disasters, including flood, violent storm, tsunami, landslide and etc.	

8.Waste-water treatment		Ecosystems like wetland and etc. could filtrate waste-water. Most of the waste-water can be decomposed by the microorganisms in the soil.	
9.Erosion prevention and maintenance of soil fertility		Grass and trees can prevent soil erosion so that providing necessary control service.	
10.Pollination		Insects and wind can provide water for growth of essential plants, including fruits, vegetables and seeds.	
11.Biological control		Urban forests are important in preventing diseases caused by plants, animals, pests and media. Urban forests ecosystems control pests and diseases through the activities of predators and parasites.	
12. Noise reduction		In the urban forest ecosystems, leafs, branches and twigs of trees can absorb noise. In addition, sound of wind through pine leafs, sound of shaking of the oak leafs or any other self-made sound can reduce noise levels.	
III.	**Habitat or Supporting services: Ecosystems provide space for plants and animals to live and maintain biodiversity.**		
13.Habitats for species		Urban forests ecosystems provide all which are necessary for animals to live such as food, water and habitat.	
14. Maintenance of genetic diversity		Genetic diversity distinguishes different species and provides the basis for locally appropriate species and gene groups.	
IV.	**Culture services: It includes immaterial benefits that people gain from cultural ecosystems. Aesthetic, mental and psychological benefits are included in the services.**		

15.Recreation and mental and physical health		There is a growing awareness of the role of green spaces in maintaining mental and physical health.	
16.Tourism		Urban forest ecosystems play an important role in the tourism sector. It provides considerably economic benefits.	
17.Aesthetic appreciation and inspiration forculture, art and design		It has been a source of inspiration for many parts of human art and culture. It also provides more and more inspiration to the field of science.	
18.Spiritual experience and sense of place		Nature is a common element that constitutes all major religions and traditional knowledge, and customs related to nature are important to form a belonging sense.	

Trade-off and Synergy effect of ecosystem service

Trade-off occurs when supplying one ecosystem service (ES) is reduced, increased use of another ES. In other words, trade-off means that as the function of an ES increases, the function of a specific ES decreases. Synergy means that as the function of an ES increases, the function of a specific ES increases.

It may vary depending on the characteristics of the target site. Even among the services of the same species, trade-off effects may happen in specific areas and synergy may occur in other areas.

According to the results of previous research, although the level and amount are different, it can be seen that trade-off effect and synergy occur simultaneously in all major classification services.

※ Please consider these points during grouping.

※ If you have any opinion about survey questionnaire and topic, please do not hesitate to describe.

Thank you very much for taking your time conducting this questionnaire survey.

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APPENDIX B Second online experts survey

Survey for the relationship between ESs

This survey is to regroup the 13 types ESs into 6 groups. The method is to do the survey about your opinion for the relationship between 2 types ecosystem services.

Ecosystem service (ES)
1.local climate and air quality regulation
2.Recreation and mental and physical health
3.Spiritual experience and sense of place
4.moderation of extreme events
5.fresh water provision
6.Aesthetic appreciation and inspiration for culture, art and design
7.Noise reduction
8.Erosion prevention and maintenance of soil fertility
9.Habitats for species
10.carbon sequestration and storage
11.Tourism
12.Biological control
13.Maintenance of genetic diversity

1-5 stands for the relationship between 2 ecosystem services.
1-Very closely related, 2-Closely related, 3-Neutral, 4-Not very related, 5-Unrelated. Please write 1 or 2 or 3 or 4 or 5 in the blank of table.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													

1) If you know how to answer above survey table, you needn't go next part. (End the survey)

---

2) If you don't know above table, please answer below questions, which are the same survey, just change the survey way.

1——Very closely related
2——Closely related
3——Neutral
4——Not very related
5——Unrelated

1) Do you think the relationship between **local climate and air quality regulation ES** and **recreation and mental and physical health ES**?

1 2 3 4 5

2) Do you think the relationship between **local climate and air quality regulation ES** and **spiritual experience and sense of place ES**?

1 2 3 4 5

3) Do you think the relationship between **local climate and air quality regulation ES** and **moderation of extreme events ES**?

1 2 3 4 5

4) Do you think the relationship between **local climate and air quality regulation ES** and **fresh water provision ES**?

1 2 3 4 5

5) Do you think the relationship between **local climate and air quality regulation ES** and **aesthetic appreciation and inspiration for culture, art and design ES**?

1 2 3 4 5

6) Do you think the relationship between **local climate and air quality regulation ES** and **noise reduction ES**?

1 2 3 4 5

7) Do you think the relationship between **local climate and air quality regulation ES** and **erosion prevention and maintenance of soil fertility ES**?

1 2 3 4 5

8) Do you think the relationship between **local climate and air quality regulation ES** and **habitats for species ES**?

1 2 3 4 5

9) Do you think the relationship between **local climate and air quality regulation ES** and **carbon sequestration and storage ES**?

1 2 3 4 5

10) Do you think the relationship between **local climate and air quality regulation ES** and **tourism ES**?

1 2 3 4 5

11) Do you think the relationship between **local climate and air quality regulation ES** and **biological control ES**?

1 2 3 4 5

12) Do you think the relationship between **local climate and air quality regulation ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

13) Do you think the relationship between **recreation and mental and physical health ES** and **spiritual experience and sense of place ES**?

1 2 3 4 5

14) Do you think the relationship between **recreation and mental and physical health ES** and **moderation of extreme events ES**?

1 2 3 4 5

15) Do you think the relationship between **recreation and mental and physical health ES** and **fresh water provision ES**?

1 2 3 4 5

16) Do you think the relationship between **recreation and mental and physical health ES** and **aesthetic appreciation and inspiration for culture, art and design ES**?

1 2 3 4 5

17) Do you think the relationship between **recreation and mental and physical health ES** and **noise reduction ES**?

1 2 3 4 5

18) Do you think the relationship between **recreation and mental and physical health ES** and **erosion prevention and maintenance of soil fertility ES**?

1 2 3 4 5

19) Do you think the relationship between **recreation and mental and physical health ES** and **habitats for species ES**?

1 2 3 4 5

20) Do you think the relationship between **recreation and mental and physical health ES** and **carbon sequestration and storage ES**?

1 2 3 4 5

21) Do you think the relationship between **recreation and mental and physical health ES** and **tourism ES**?

1 2 3 4 5

22) Do you think the relationship between **recreation and mental and physical health ES** and **biological control ES**?

1 2 3 4 5

23) Do you think the relationship between **recreation and mental and physical health ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

24) Do you think the relationship between **spiritual experience and sense of place ES** and **moderation of extreme events ES**?

1 2 3 4 5

25) Do you think the relationship between **spiritual experience and sense of place ES** and **fresh water provision ES**?

1 2 3 4 5

26) Do you think the relationship between **spiritual experience and sense of place ES** and **aesthetic appreciation and inspiration for culture, art and design ES**?

1 2 3 4 5

27) Do you think the relationship between **spiritual experience and sense of place ES** and **noise reduction ES**?

1 2 3 4 5

28) Do you think the relationship between **spiritual experience and sense of place ES** and **erosion prevention and maintenance of soil fertility ES**?

1 2 3 4 5

29) Do you think the relationship between **spiritual experience and sense of place ES** and **habitats for species ES**?

1 2 3 4 5

30) Do you think the relationship between **spiritual experience and sense of place ES** and **carbon sequestration and storage ES**?

1 2 3 4 5

31) Do you think the relationship between **spiritual experience and sense of place ES** and **tourism ES**?

1 2 3 4 5

32) Do you think the relationship between **spiritual experience and sense of place ES** and **biological control ES**?

1 2 3 4 5

33) Do you think the relationship between **spiritual experience and sense of place ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

34) Do you think the relationship between **moderation of extreme events ES** and **fresh water provision ES**?

1 2 3 4 5

35) Do you think the relationship between **moderation of extreme events ES** and **aesthetic appreciation and inspiration for culture, art and design ES**?

1 2 3 4 5

36) Do you think the relationship between **moderation of extreme events ES** and **noise reduction ES**?

1 2 3 4 5

37) Do you think the relationship between **moderation of extreme events ES** and **erosion prevention and maintenance of soil fertility ES**?

1 2 3 4 5

38) Do you think the relationship between **moderation of extreme events ES** and **habitats for species ES**?

1 2 3 4 5

39) Do you think the relationship between **moderation of extreme events ES** and **carbon sequestration and storage ES**?

1 2 3 4 5

40) Do you think the relationship between **moderation of extreme events ES** and **tourism ES**?

1 2 3 4 5

41) Do you think the relationship **moderation of extreme events ES** and **biological control ES**?

1 2 3 4 5

42) Do you think the relationship between **moderation of extreme events ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

43) Do you think the relationship between **fresh water provision ES** and **aesthetic appreciation and inspiration for culture, art and design ES**?

1 2 3 4 5

44) Do you think the relationship between **fresh water provision ES** and **noise reduction ES**?

1 2 3 4 5

45) Do you think the relationship between **fresh water provision ES** and **erosion prevention and maintenance of soil fertility ES**?

1 2 3 4 5

46) Do you think the relationship between **fresh water provision ES** and **habitats for species ES**?

1 2 3 4 5

47) Do you think the relationship between **fresh water provision ES** and **carbon sequestration and storage ES**?

1 2 3 4 5

48) Do you think the relationship between **fresh water provision ES** and **tourism ES**?

1 2 3 4 5

49) Do you think the relationship between **fresh water provision ES** and **biological control ES**?

1 2 3 4 5

50) Do you think the relationship between **fresh water provision ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

51) Do you think the relationship between **aesthetic appreciation and inspiration for culture, art and design ES** and **noise reduction ES**?

1 2 3 4 5

52) Do you think the relationship between **aesthetic appreciation and inspiration for culture, art and design ES** and **erosion prevention and maintenance of soil fertility ES**?

1 2 3 4 5

53) Do you think the relationship between **aesthetic appreciation and inspiration for culture, art and design ES** and **habitats for species ES**?

1 2 3 4 5

54) Do you think the relationship between **aesthetic appreciation and inspiration for culture, art and design ES** and **carbon sequestration and storage ES**?

1 2 3 4 5

55) Do you think the relationship between **aesthetic appreciation and inspiration for culture, art and design ES** and **tourism ES**?

1 2 3 4 5

56) Do you think the relationship between **aesthetic appreciation and inspiration for culture, art and design ES** and **biological control ES**?

1 2 3 4 5

57) Do you think the relationship between **aesthetic appreciation and inspiration for culture, art and design ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

58) Do you think the relationship between **noise reduction ES** and **erosion prevention and maintenance of soil fertility ES**?

1 2 3 4 5

59) Do you think the relationship between **noise reduction ES** and **habitats for species ES**?

1 2 3 4 5

60) Do you think the relationship between **noise reduction ES** and **carbon sequestration and storage ES**?

1 2 3 4 5

61) Do you think the relationship between **noise reduction ES** and **tourism ES**?

1 2 3 4 5

62) Do you think the relationship between **noise reduction ES** and **biological control ES**?

1 2 3 4 5

63) Do you think the relationship between **noise reduction ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

64) Do you think the relationship between **erosion prevention and maintenance of soil fertility ES** and **habitats for species ES**?

1 2 3 4 5

65) Do you think the relationship between **erosion prevention and maintenance of soil fertility ES** and **carbon sequestration and storage ES**?

1 2 3 4 5

66) Do you think the relationship between **erosion prevention and maintenance of soil fertility ES** and **tourism ES**?

1 2 3 4 5

67) Do you think the relationship between **erosion prevention and maintenance of soil fertility ES** and **biological control ES**?

1 2 3 4 5

68) Do you think the relationship between **erosion prevention and maintenance of soil fertility ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

69) Do you think the relationship between **habitats for species ES** and **carbon sequestration and storage ES**?

1 2 3 4 5

70) Do you think the relationship between **habitats for species ES** and **tourism ES**?

1 2 3 4 5

71) Do you think the relationship between **habitats for species ES** and **biological control ES**?

1 2 3 4 5

72) Do you think the relationship between **habitats for species ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

73) Do you think the relationship between **carbon sequestration and storage ES** and **tourism ES**?

1 2 3 4 5

74) Do you think the relationship between **carbon sequestration and storage ES** and **biological control ES**?

1 2 3 4 5

75) Do you think the relationship between **carbon sequestration and storage ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

76) Do you think the relationship between **tourism ES** and **biological control ES**?

1 2 3 4 5

77) Do you think the relationship between **tourism ES** and **maintenance of genetic diversity ES**?

1 2 3 4 5

78) Do you think the relationship between **biological control ES** and **maintenance of genetic diversity ES**?

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APPENDIX C Third online experts survey

Expert Questionnaire Survey for Defining the Attributes of Urban Forest Ecosystem Services

Hello! I am Han Zhiying, a student of taking master courses in the department of forest sciences, Seoul National University.

Through Delphi method, online survey was done twice, with 30 experts as respondents, to rank the importance of 18 ecosystem service (ES) types. Rank No.14 to No.18 were omitted since their importance values were very low. The results are shown below.

Rank	Urban forest ecosystem services	Importance Value
1	Local climate and air quality regulation	90
2	Carbon sequestration and storage	86
3	Recreation and mental and physical health	74
4	Fresh water provision	72
5	Noise reduction	72
6	Moderation of extreme events	69
7	Spiritual experience and sense of place	69
8	Erosion prevention and maintenance of soil fertility	67
9	Aesthetic appreciation and inspiration for culture, art and design	65
10	Maintenance of genetic diversity	62
11	Tourism	58
12	Habitats for species	57
13	Biological control	52
14	Waste-water treatment	42
15	Pollination	38
16	Food	36
17	Medicinal resources	35
18	Raw materials	33

[*Note: Rank No.14 (Waste-water treatment), No.15 (Pollination), No.16 (Food), No. 17 (Medicinal resources) and No.18 (Raw materials) will not be considered for selection of urban forest ES attributes.]

In the next stage, another online survey was conducted with 22 experts as respondents. This is to regroup the remaining 13 ES types into 6 groups. The results of regrouping are shown below.

1. Fresh water provision
2. Noise reduction
3. Soil conservation (including moderation of extreme events)
4. Climate and air quality regulation (including climate change mitigation)
5. Biodiversity conservation

6. Cultural service (including recreation, tourism, aesthetic appreciation and spiritual experience)

Citizens' preferences toward urban forests may depend on the level of attributes of urban forest ecosystem services. The study focuses on the 6 ES types regrouped, and their attributes and the levels. To guide the respondents in understanding the attribute levels of urban forests, indicators and illustrations to explain the different levels of attributes were presented.

First, please choose the attribute option including the level (and indicator), which can best be used to measure the quantity and/or quality of ES in question. Then, if you do not agree with the options of measuring the ES attribute, please suggest how to measure the ES attribute.

The survey is consist of 7 parts (including 7 questions) and will require less than 20 minutes to finish. The results of this survey questionnaire will be used for academic purposes only.

Thank you for taking your time conducting this questionnaire survey. Wish you good health and prosperity!

Han Zhiying

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※ If you have any other questions, please do not hesitate to contact the author.
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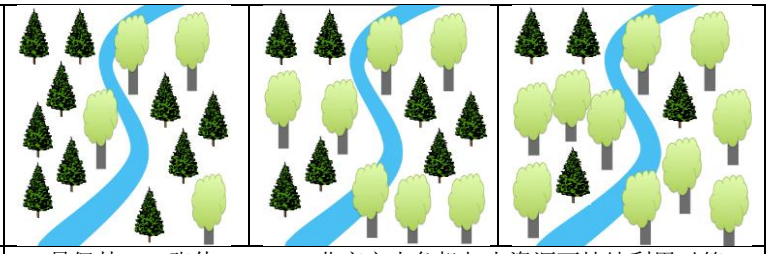
Adviser: Professor Youn Yeo-chang
□ Email: youn@snu.ac.kr **□ Phone number: +82-2-880-4754**

Part 1

This part focuses on the ES of fresh water provision. The fresh water accessible to the people in Beijing mainly includes surface water, groundwater and transit water, which is function of the total runoff (Wu and Zhang, 2005). Biao et al. (2010) reported that the amount of surface runoff in broadleaved forest (like Q. liaotungensis) was 31.31 m3/ha, and the broadleaved forest was the largest contributor to the service of fresh water provision in Beijing.

Attribute	Fresh water provision		
Indicator	Proportion of broadleaf trees		
Attribute level	The ES of fresh water provision is low, if broadleaf trees compose 25% and below of the forest.	The ES of fresh water provision is middle, if broadleaf trees compose 25-75% of the forest.	The ES of fresh water provision is high, if broadleaf trees compose 75% and above of the forest.

Illustration	
Reference	1. 吴佩林, & 张伟. (2005). 北京市水危机与水资源可持续利用对策. 辽宁工程技术大学学报, 24(3), 436-439. 2. Biao, Z., Wenhua, L., Gaodi, X., & Yu, X. (2010). Water conservation of forest ecosystem in Beijing and its value. Ecological Economics, 69(7), 1416-1426.

Question 1: Do you agree with the attribute and attribute level?

1) Agree 2) Disagree

(If you do not agree with the option of measuring the ES attribute, please suggest how to measure the ES attribute.)

Attribute			
Indicator			
Attribute level			
Explain the rationale for the suggested option			
Reference			

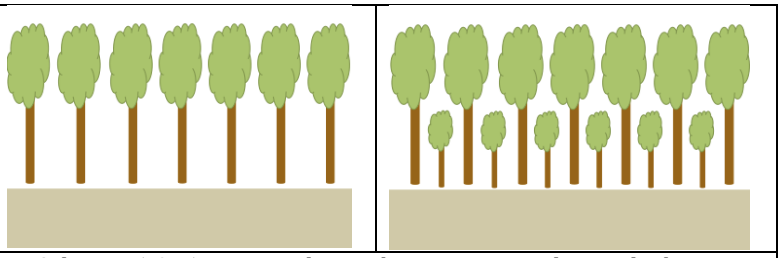
Part 2

A law was passed in the People's Republic of China concerning on the regulation of environmental pollution. Stipulated in the law, noise pollution cannot exceed 45dB. This part focuses on the ES of noise reduction. There are two options for noise reduction indicators. First, please choose the attribute option including the level (and indicator), which can best be used to measure the quantity and/or quality of noise reduction ES in question. Then, if you do not agree with the options of measuring the ES attribute, please suggest how to measure the ES attribute.

Option 1

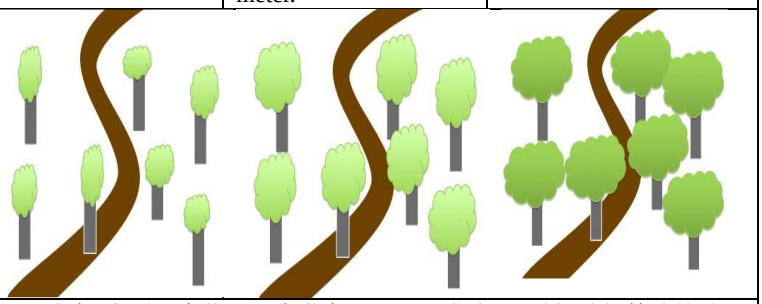
Aylor (1972) reported that the foliage of trees reduces noise and absorbs noise pollution. In all of the vegetation belts examined, shrubs were the most effective in reducing noise owing to scattering from their dense foliage and branches (Fang and Ling, 2003).

Attribute	**Noise Reduction**	
Indicator	Floral composition	
Attribute level	The ES of noise reduction is low, if only trees were present.	The ES of noise reduction is high, if trees and shrubs were present.

Illustration	
Reference	1. Aylor, D. (1972). Noise reduction by vegetation and ground. The Journal of the Acoustical Society of America, 51(1B), 197-205. 2. Fang, C. F., & Ling, D. L. (2003). Investigation of the noise reduction provided by tree belts. *Landscape and urban planning*, *63*(4), 187-195.

Option 2

According to Ba (2013), tree crown diameter is positively correlated to noise reduction. If tree crown diameter is small, the ES of noise reduction is relatively low; on the contrary, if tree crown diameter is large, the ES of noise reduction is relatively high.

Attribute	**Noise Reduction**		
Indicator	Tree crown diameter		
Attribute level	The ES of noise reduction is low, if tree crown diameter is less than 0.34 meter.	The ES of noise reduction is middle, if tree crown diameter ranges 0.34-1.02 meter.	The ES of noise reduction is high, if tree crown diameter is more than 1.02 meter.
Illustration			
Reference	1. 巴成宝, 梁冰, 秦仲, & 李湛东. (2013). 北京 4 种阔叶绿篱球的减噪效应及其影响因子. 城市环境与城市生态, 26(2), 14-19.		
Note	1. The average tree crown diameter of single plant is 0.679 meter (Ba et al., 2013). 2. Among, 0.34 is half of average (0.679), and 1.02 is 1.5 times of average.		

Question 2: Do you agree with option 1 or option 2?

1) Option 1 2) Option 2

(If you do not agree with the options of measuring the ES attribute, please suggest how to measure the ES attribute.)

Attribute			
Indicator			
Attribute level			

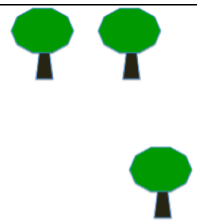
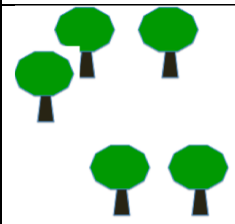
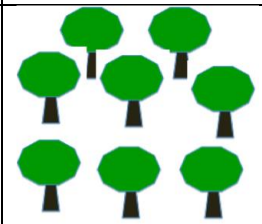
Explain the rationale for the suggested option			
Reference			

Part 3

This part focuses on the ES of soil conservation (including moderation of extreme events). There are two candidates for this ES type. First, please choose the attribute option including the level (and indicator), which can best be used to measure the quantity and/or quality of noise reduction ES in question. Then, if you do not agree with the options of measuring the ES attribute, please suggest how to measure the ES attribute.

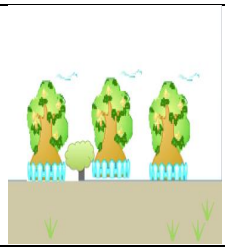
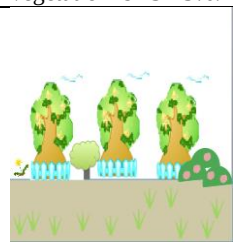
Option 1

He et al. (2012) reported that stand density is positively correlated to soil conservation. If stand density is small, the ES of soil conservation is relatively low; on the contrary, if the stand density is large, the ES of soil conservation is relitively high.

Attribute	**Soil Conservation**		
Indicator	Stand density		
Attribute level	The ES of soil conservation is low, if stand density is less than 700 trees/ha.	The ES of soil conservation is middle, if stand density ranges 700-2100 trees/ha.	The ES of soil conservation is high, if stand density is more than 2100 trees/ha.
Illustration			
Reference	1. 贺宇, 丁国栋, 梁文俊, 臧荫桐, 高广磊, & 安云. (2012).林分密度对枯落物层持水特性的影响. 西北农林科技大学学报: 自然科学版, 40(4), 68-72.		
Note	1. The average stand density is 1400 trees/ha (He et al., 2012). 2. Among, 700 is half of average (1400), and 2100 is 1.5 times of average.		

Option 2

Miller et al. (2015) mentioned that it is necessary to conserve surface soil as it supports the increase of soil pore spaces, which also contributes to effective prevention of soil loss and landslides. Zhao and Ouyang (2015) reported that the coverage of low-lying vegetation contributes to the prevention of soil loss and landslides by maintaining pore spaces within the soil. The coverage of low-lying vegetation is positively correlated to the prevention of soil loss and landslides.

Attribute	**Moderation of extreme events (landslide)**		
Indicator	Coverage of low-lying vegetation		
Attribute level	The prevention of soil loss and landslides is low, if the coverage of low-lying vegetation is below 25%.	The prevention of soil loss and landslides is medium, if the coverage of low-lying vegetation is 25-75%.	The prevention of soil loss and landslides is high, if the coverage of low-lying vegetation is above 75%.
Illustration			
Reference	1. Miller, R. W., Hauer, R. J., & Werner, L. P. (2015). Urban forestry: planning and managing urban green spaces. Waveland press. 2. 赵芳, & 欧阳勋志. (2015). 飞播马尾松林林下植被盖度与环境因子的关系. 应用生态学报, 26(4), 1071-1076.		

Question 3: Do you agree with option 1 or option 2?

1) Option 1 2) Option 2

(If you do not agree with the options of measuring the ES attribute, please suggest how to measure the ES attribute.)

Attribute			
Indicator			
Attribute level			
Explain the rationale for the suggested option			
Reference			

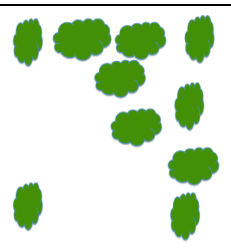
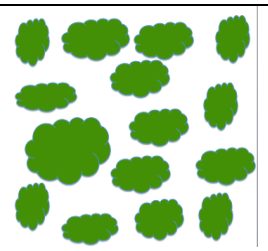
Part 4

This part focuses on the ES of climate and air quality regulation (including climate change mitigation). There are two candidates for this ES type. First, please choose the attribute option including the level (and indicator), which can best be used to measure the quantity and/or quality of noise reduction ES in question. Then, if you do not agree with the options of measuring the ES attribute, please suggest how to measure the ES attribute.

Option 1

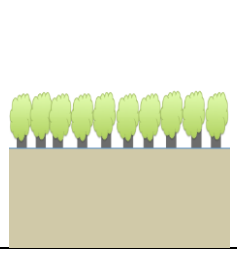
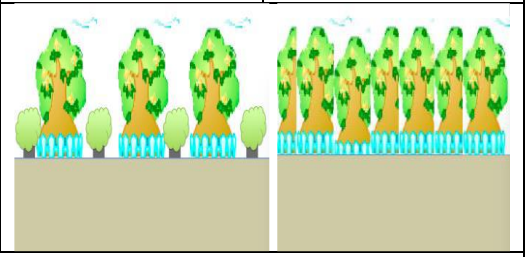
Garden plants have a significant ability to remove air particulate matters (PM) and can effectively improve the urban environmental quality (Chen et al., 2014). Nowak et al. (2006) reported that urban trees' contribution to air pollution reduction, pollution removal of pollutants is affected by the amount of tree crown coverage in the city. That is, if the tree crown coverage is small, the air quality regulation is relatively low. On the contrary, if the tree

crown coverage is large, the air quality regulation is relatively high.

Attribute	**Air Quality Regulation**		
Indicator	Tree crown coverage		
Attribute level	The ES of air quality regulation is low, if tree crown coverage is below 25%.	The ES of air quality regulation is middle, if tree crown coverage is 25-75%.	The ES of air quality regulation is high, if tree crown coverage is above 75%.
Illustration (vertical view)			
Reference	1. 陈小平, 焦奕雯, 裴婷婷, & 周志翔. (2014). 园林植物吸附细颗粒物 (PM 2.5) 效应研究进展. 生态学杂志, 33(9), 2558-2566. 2. Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. Urban forestry & urban greening, 4(3), 115-123.		

Option 2

Li et al. (2017) reported that 1 hm2 broad-leaved forest can absorb 1000kg CO2, and release 730kg O2. According to Wang et al. (2007), greenspaces can absorb CO2 is 1.767 ton/ha/day and release 1.23 ton/ha/day O2, among arbor forest took up the largest proportion. The capacity of mitigating CO2 of tall trees is larger than shrub. The higher ratio of tall trees, the larger carbon sequestration of the forest.

Attribute	**Carbon Sequestration**		
Indicator	Proportion of tall trees		
Attribute level	The ES of carbon sequestration is low, if the proportion of tall trees is below 25%.	The ES of carbon sequestration is middle, if the proportion of tall trees is 25-75%.	The ES of carbon sequestration is high, if the proportion of tall trees is above 75%.
Illustration			
References	1. 李慧, 李春义, & 南海龙. (2017). 森林疗养. 风景园林, (5), 44-51. 2. 王丽勉, 胡永红, 秦俊, 高凯, & 黄娟. (2007). 上海地区 151 种绿化植物固碳释氧能力的研究. 华中农业大学学报, 26(3), 399-401.		

Question 4: Do you agree with option 1 or option 2?

1) Option 1 2) Option 2

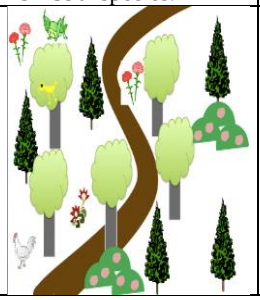
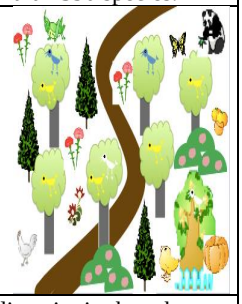
(If you do not agree with the options of measuring the ES attribute, please suggest how to

measure the ES attribute.)

Attribute			
Indicator			
Attribute level			
Explain the rationale for the suggested option			
Reference			

Part 5

This part focuses on the ES of biodiversity conservation. Alvey (2006) reported urban forests play a significant role in maintaining wildlife habitats. Piao (2014) grouped the trees into two levels -- fruit trees and non-fruit trees, based on the assumption that more fruit trees can attract more birds and animals by providing fruits. While taking into consideration species diversity and wildlife habitat, the number of plant species can be used as an indicator for biodiversity of urban forests; this can be classified into poor, middle, or rich (Koo et al., 2013).

Attribute	**Species diversity and wildlife habitat**		
Indicator	The number of plant species/km2		
Attribute level	The species diversity and wildlife habitat is poor, if the number of plant species is less than 197 species.	The species diversity and wildlife habitat is middle, if the number of plant species ranges 197-590 species.	The species diversity and wildlife habitat is rich, if the number of plant species is more than 590 species.
Illustration			
Reference	1. Alvey, A. A. (2006). Promoting and preserving biodiversity in the urban forest. Urban Forestry & Urban Greening, 5(4), 195-201. 2. 박미연. (2014). A choice-based conjoint analysis of public preferences on urban tree attributes in Shanghai, China (Doctoral dissertation, 서울대학교 대학원). 3. Koo, J. C., Park, M. S., & Youn, Y. C. (2013). Preferences of urban dwellers on urban forest recreational services in South Korea. Urban forestry & urban greening, 12(2), 200-210. 4. 郑瑞文, & 刘艳红. (2006). 北京市公园绿地植物多样性研究. 科学技术与工程, 6(15), 2309-2315.		

Note	1. There are 393 plants species, which belonged to 251 genera and 90 families in Beijing parks (Zheng and Liu, 2006). 2. Among, 197 is half of average (393), and 590 is 1.5 times of average.

Question 5: Do you agree with the attribute and attribute level?

1) Agree 2) Disagree

(If you do not agree with the option of measuring the ES attribute, please suggest how to measure the ES attribute.)

Attribute			
Indicator			
Attribute level			
Explain the rationale for the suggested option			
Reference			

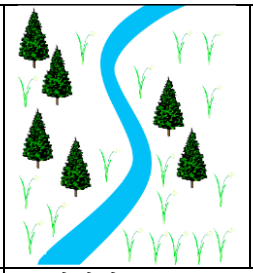
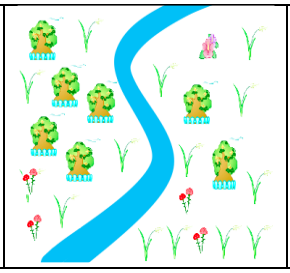
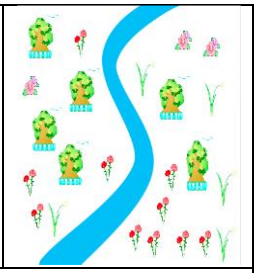
Part 6

This part focuses on cultural ecosystem service (CES). There are two candidates for this ES type. First, please choose the attribute option including the level (and indicator), which can best be used to measure the quantity and/or quality of noise reduction ES in question. Then, if you do not agree with the options of measuring the ES attribute, please suggest how to measure the ES attribute.

Option 1

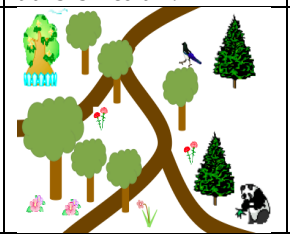
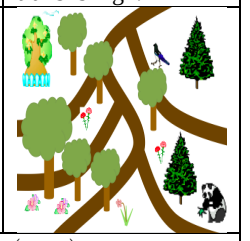
According to Piao (2014), aesthetic function of urban trees includes seasonal dynamics of leaf and the color of flower of trees. We followed the classification of Li et al. (2006) who used the change of leaves' color as the criteria. Urban forests are classified into evergreen forest and non-evergreen forest according to whether there is seasonal color change of leaf (Shi et al., 2010).

Attribute	**Aesthetic Appreciation**		
Indicator	Proportion of flowering and trees changing leaf color		
Attribute level	Aesthetic appreciation is low (CES is relatively low), if flowering and trees changing leaf color is below 25% of the tree species of the forest.	Aesthetic appreciation is middle (CES is relatively middle), if flowering and trees changing leaf color is 25-75% of the tree species of the forest.	Aesthetic appreciation is high (CES is relatively high), if flowering and trees changing leaf color is above 75% of the tree species of the forest.

Illustration			
Reference	1. 박미연. (2014). A choice-based conjoint analysis of public preferences on urban tree attributes in Shanghai, China (Doctoral dissertation, 서울대학교 대학원). 2. 李玉萍, 李宏, & 夏和宝. (2006). 彩叶植物资源及其在南京园林中的应用. 金陵科技学院学报, 22(1), 95-100. 3. 史继术, 马斌, & 罗言云. (2010). 植物叶色成因及其园林应用. 安徽農業科學, 38(10), 5089-5090+.		

Option 2

Trails are the pathways where visitors spend most of their time in urban forests. Koo et al. (2013) reported that trails are regarded as an important part of forest recreation infrastructure in Korean social and culture. The levels of trails' density were expressed by the amount of time spent by a visitor walking in the urban forests. These levels were set according to the average time (1 hour per day) Beijing citizens spend time in urban forests (Li and Fan, 1999). The larger the trail density of the forest, the more people can enjoy ES of recreation and therapy of forest.

Attribute	**Recreation and Spiritual Experience**		
Indicator	Density of trails		
Attribute level	The ES of recreation and therapy service is low, if density of trails is low.	The ES of recreation and therapy service is medium, if density of trails is medium.	The ES of recreation and therapy service is high, if density of trails is high.
Illustration			
Reference	1. Koo, J. C., Park, M. S., & Youn, Y. C. (2013). Preferences of urban dwellers on urban forest recreational services in South Korea. Urban forestry & urban greening, 12(2), 200-210. 2. 李迪华, & 范闻捷. (1999). 北京香山公园锻炼身体人群研究. 中国园林, 15(2), 64-67. 3. 李慧, 李春义, & 南海龙. (2017). 森林疗养. 风景园林, (5), 44-51.		

Question 6: Do you agree with option 1 or option 2?

1) Option 1 2) Option 2

(If you do not agree with the options of measuring the ES attribute, please suggest how to measure the ES attribute.)

Attribute			
Indicator			
Attribute level			
Explain the rationale for the suggested option			
Reference			

Part 7

This part focuses on municipality tax, a special tax for the management of urban forests every year. Shi (2015) set the attribute levels to be 0 RMB, 5 RMB, 10 RMB, 20RMB, 50RMB, 100RMB as the annual tax per household in order to calculate the value for enhancing and maintaining the public function/ utility of Wenjiang forests. The price that the surveyed citizens are willing to pay for protection of old and famous trees in Beijing was 10-20 RMB/person/year (Lei et al., 2017). Zhang and Qi (2016) reported Beijing citizens were willing to pay 50-100 RMB/household/year for governance haze. Considering the characteristics, scope, and targets of previous studies, we set the attribute levels for the annual municipality tax to be 25, 50 and 100 RMB/household (4300, 8600 and 17200 Won/household) as these prices are located between the 3 price ranges (1 RMB = 6.63 USD, 1 RMB = 172.64 Won).

Attribute	**Municipality Tax**		
Indicator	Level of payment		
Attribute level	A household is willing to pay 4300 Won/year in the form of amount of municipality tax, if their willingness-to-pay for enhancing urban forest ES is relatively low.	A household is willing to pay 8600 Won/year in the form of amount of municipality tax, if their willingness-to-pay for enhancing urban forest ES is on average.	A household is willing to pay 12900 Won/year in the form of amount of municipality tax, if their willingness-to-pay for enhancing urban forest ES is relatively high.
Reference	1. 石春娜. (2015). 基于 Mixed Logit 模型的温江生态系统服务支付意愿影响因素研究. 林业经济, 9, 005. 2. 雷硕, 马奔, & 温亚利. (2017). 北京市民对古树名木保护支付意愿及影响因素研究. 干旱区资源与环境, (4), 73-79. 3. 张廷玉, & 祁新华. (2016). 雾霾治理的支付意愿研究——基于北京与福州的对比. 理论视野, (7), 83-85.		
Note	1. Among, 4300 is half of average (8600), and 12900 is 1.5 times of average.		

Question 7: Are you willing to pay 8600 Won/household/year for enhancing urban forest ES in the form of environmental tax to the municipality government of your municipality? (1000 Won = 0.87 USD)

☐ Yes. I am willing to pay the amount as additional tax.  Then, are you willing to pay 12900 Won/household/year for enhancing urban forest ES the form of environmental tax to the municipality government of your municipality? 1) Yes 2) No	☐ No. I am not willing to pay the amount as additional tax.  Then, are you willing to pay 4300 Won/household/year for enhancing urban forest ES the form of environmental tax to the municipality government of your municipality? 1) Yes 2) No

※Thank you very much for participating in this questionnaire survey※

APPENDIX D Main Choice Experiments Survey (2017 October) (English)

Survey on Beijing citizens' preferences for ecosystem services provided by urban forests

서울대학교

Hello! I am a student of taking master courses in the department of forest sciences, Seoul National University. The study aims to investigate public preferences for ecosystem services provided by Beijing urban forests. It consists of 4 parts – Parts A, B, C and D. Your answers are very important for the succeeding of the study, and the results of the study can be taken into account in the establishment of urban forest policy, which can increase citizens' benefits and satisfaction for urban forests. The results of this survey questionnaire will be used for academic purposes only. Thank you very much for taking your time conducting this questionnaire survey. Wish you good health and prosperity! If you have any other questions, please do not hesitate to contact me.

Han Zhiying (hanzhiying@snu.ac.kr)
Ecological Economics Laboratory, Department of Forest Sciences, Seoul National University

Version 1	Date:

※ **Residential area now**

1. 东城区、2. 西城区、3. 朝阳区、4. 丰台区、5. 石景山区、6. 海淀区、7. 顺义区、8. 通州区、9. 大兴区、10. 房山区、11. 门头沟区、12. 昌平区、13. 平谷区、14. 密云区、15. 怀柔区、16.延庆区

Q 1. Your age (as of 1 August 2017) _____ years old → If you are below 20 years old, please stop to do the survey.

Q 2. How many years did you live in Beijing (as of 1 August 2017)? _____ years → If you lived in Beijing within 1 year, please stop to do the survey.

※ Answer the survey questionnaire before, please read the introduction of urban forest.

An urban forest means "a forest within a city" and it includes any kind of forest grow in a park, a palace, an embankment, a garden, a school in the city and suburb and along the street.

There are urban forests, including urban parks, urban country parks, forest parks, scenic areas and nature reserves in different region of Beijing.

Q 3. Have you ever been to one of urban forests in 2016?

1) Yes → Please go A1. 2) No → Please stop to do the survey.

(A) There are some questions about attitude for urban forests.

A1. How often did you visit urban forests in 2016? _____ visit(s) per month

A2. What is your biggest purpose of visiting an urban forest? (Rank 1:____, Rank2:____, Rank3: _____)

1) Exercise for health 2) Relaxation 3) Promote friendship 4) Natural scenery appreciation

5) Escape from daily life 6) Others (Please state _____)

A3. What is your degree of satisfaction to the urban forest near your home?
1) Very dissatisfied 2) Dissatisfied 3) Neutral 4) Satisfied 5) Very satisfied

A4. How long it will take if you walk to the urban forest near your home?
1) Less than 20 minutes 2) 20~39 minutes 3) 40~59 minutes
4) 60-120 minutes 5) More than 2 hour

A5. Do you think the scale of urban forest in Beijing is enough?
1) Very insufficient 2) Insufficient 3) Neutral 4) Sufficient 5) Very sufficient

A6. How important do you think an urban forest is relative to river, farmland and lawn?
1) Much less important 2) Less important 3) Similar
4) More important 5) Much more important

A7. How much are you emotionally connected to Beijing?
1) Much less deep 2) Less deep 3) Middle
4) More deep 5) Much more deep

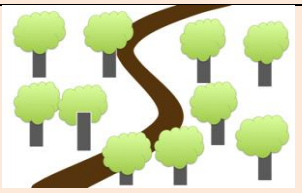
(B) The following questions are related to urban forest ecosystem services.

※ Answer the survey questionnaire before, please read the introduction of ecosystem services.

Ecosystem services refer to the benefits that human gain from the ecosystem. Ecosystem services can be divided into four categories: provisioning services, regulating services, habitat services, and cultural services.

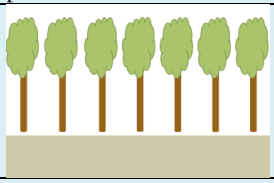
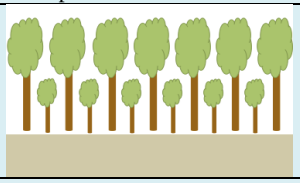
Note: There is a trade-off relationship between these ecosystem services. A trade-off is a relationship when one ecosystem service function increases, other ecosystem services function decrease. A companion relationship means that as one ecosystem service function increases, other ecosystem services function also increase. Please consider about these when you choose the answer.

Urban forest ecosystem can ensure flow, conservation and purification of water and play an important role in the supply of drinking water. Grass, trees and forest can have influence on the amount of available water.

Attribute	**Fresh water provision**	
Indicator	Proportion of broadleaf trees	
Attribute level	The ES of fresh water provision is low, if it has only softwood.	The ES of fresh water provision is high, if it has only hardwood.
Illustration		

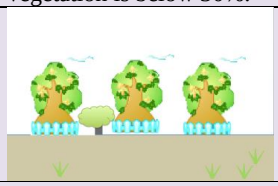
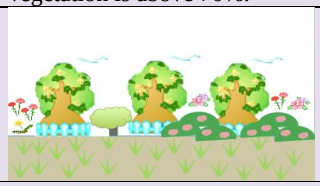
B1. How much do you think fresh water provision ecosystem service is important?
1) Much less important 2) Less important 3) Medium 4) More important
5) Much more important

In the urban forest ecosystem, branches and twigs of trees can absorb noise. In addition, sound of wind through pine, sound of shaking of the oak or any other self-made sound can reduce noise levels.

Attribute	**Noise Reduction**	
Indicator	Floral composition	
Attribute level	The ES of noise reduction is low, if only trees were present.	The ES of noise reduction is high, if both trees and shrubs were present.
Illustration		

B2. How much do you think noise reduction ecosystem service is important?
1) Much less important 2) Less important 3) Medium 4) More important
5) Much more important

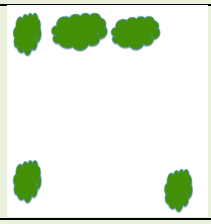
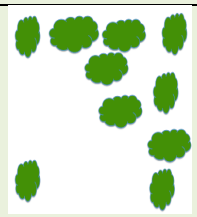
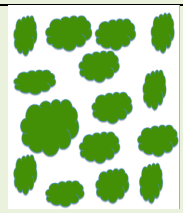
Organisms in the urban forest ecosystem can create cushion for the natural disasters and reduce the loss caused by the extreme weathers and disasters, including flood, violent storm, tsunami, landslide and etc.

Attribute	**Moderation of extreme events (landslide)**	
Indicator	Coverage of low-lying vegetation	
Attribute level	The prevention of soil loss and landslides is low, if the coverage of low-lying vegetation is below 30%.	The prevention of soil loss and landslides is high, if the coverage of low-lying vegetation is above 70%.
Illustration		

B3. How much do you think Moderation of extreme events ecosystem service is important?
1) Much less important 2) Less important 3) Medium 4) More important
5) Much more important

Urban forest ecosystem can have the capacity of carbon sequestration so that regulate climate. Trees and grassland can reduce the temperature of urban area and play a role in regulating air quality by removing pollutant in the atmosphere.

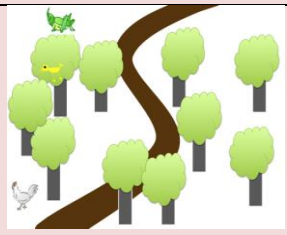
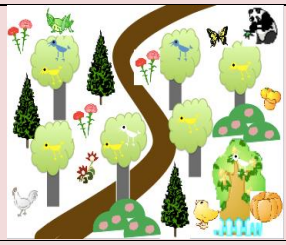
Attribute	**Air Quality Regulation**
Indicator	Tree crown coverage

Attribute level	The ES of air quality regulation is low, if tree crown coverage is below 25%.	The ES of air quality regulation is middle, if tree crown coverage is 25-75%.	The ES of air quality regulation is high, if tree crown coverage is above 75%.
Illustration (vertical view)			

B4. How much do you think air quality regulation ecosystem service is important?

1) Much less important 2) Less important 3) Medium 4) More important 5) Much more important

Urban forests ecosystem provides all which are necessary for animals to live such as food, water and habitat. When all migrant species move, various habitats which may be necessary for the life cycle of a species are provided.

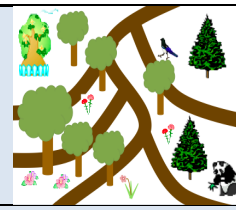
Attribute	**Species diversity and wildlife habitat**	
Indicator	The number of plant species/km2	
Attribute level	The species diversity and wildlife habitat is low, if the forest is composed of a single species of tree.	The species diversity and wildlife habitat is rich, if the forest is composed of multiple species of tree and shrubs.
Illustration		

B5. How much do you think species diversity and wildlife habitat ecosystem service is important?

1) Much less important 2) Less important 3) Medium 4) More important 5) Much more important

Walking and exercising in green spaces like urban forests is good physical activities helping people relax. There is a growing awareness of the role of green spaces in maintaining mental and physical health.

Attribute	**Recreation and Spiritual Experience**		
Indicator	Density of trails		
Attribute level	The ES of recreation and therapy service is low, if density of trails is low.	The ES of recreation and therapy service is medium, if density of trails is medium.	The ES of recreation and therapy service is high, if density of trails is high.

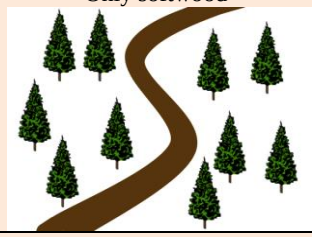
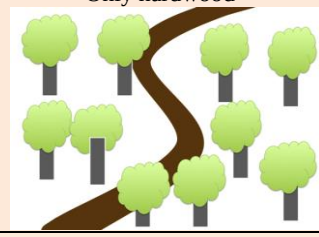
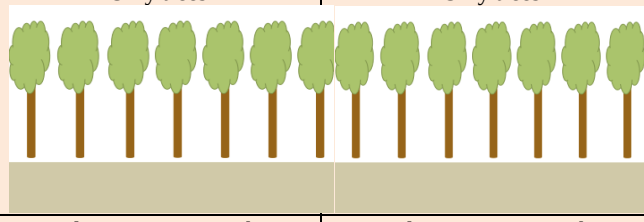
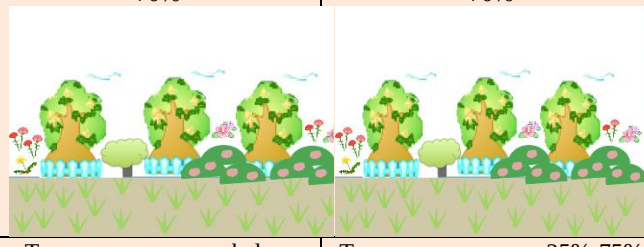
Illustration			

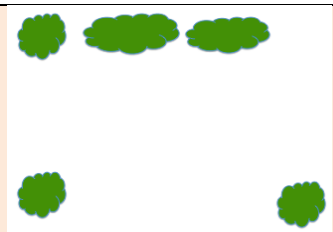
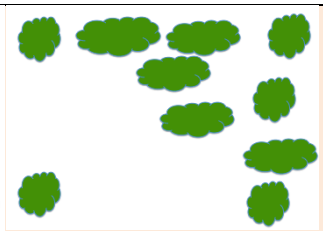
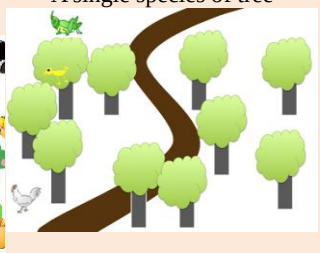
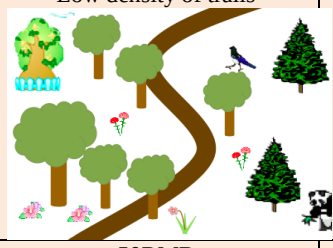
B6. How much do you think recreation and spiritual experience ecosystem service is important?

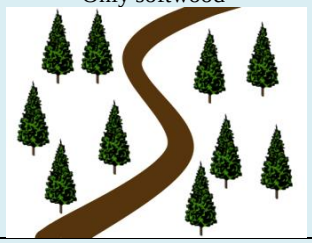
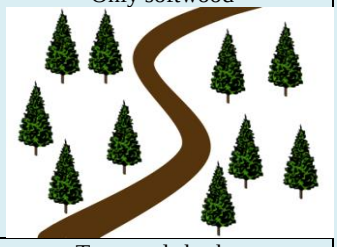
1) Much less important 2) Less important 3) Medium 4) More important 5) Much more important

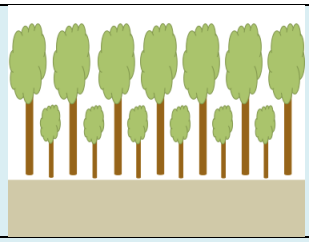
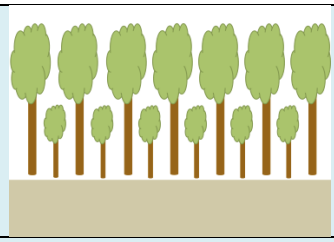
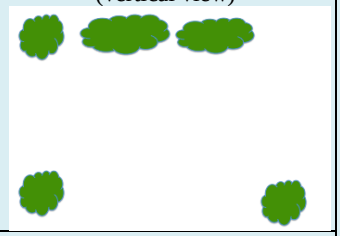
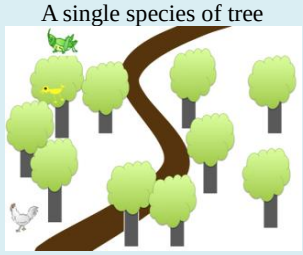
(C) There are questions about preference of urban forest ecosystem services.

C1. Which of the following urban forest ecosystem services do you favor? Option A and option B would entail a cost to your household. No payment would be required for "Neither A nor B" option.

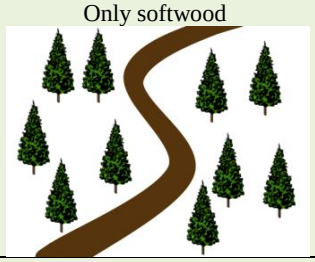
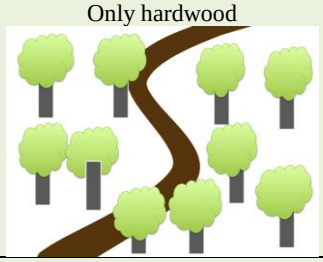
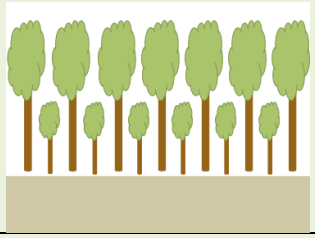
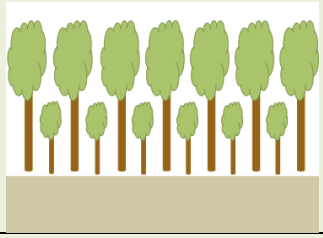
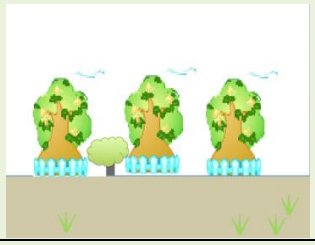
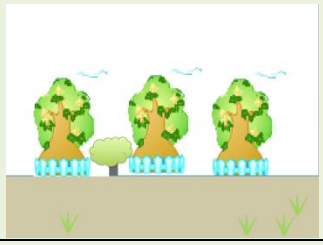
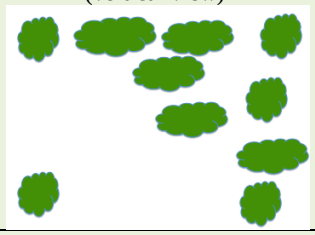
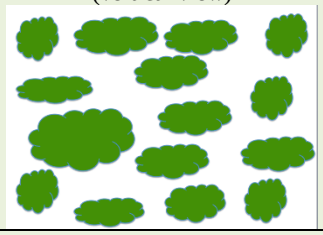
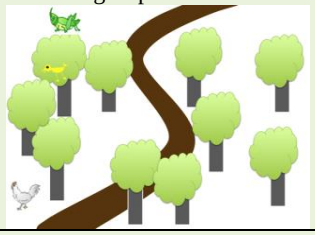
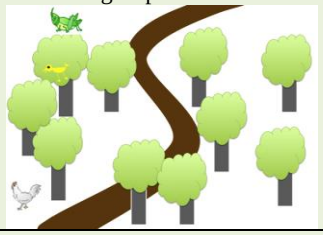
	Scenario A	Scenario B	
Fresh water provision	Only softwood 	Only hardwood 	
Noise reduction	Only trees 	Only trees	
Moderation of extreme events (landslide)	Low-lying vegetation above 70% 	Low-lying vegetation above 70%	Neither A nor B
Air quality regulation	Tree crown coverage below 25% (vertical view)	Tree crown coverage 25%-75% (vertical view)	

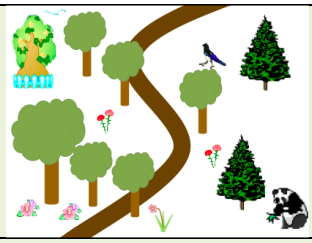
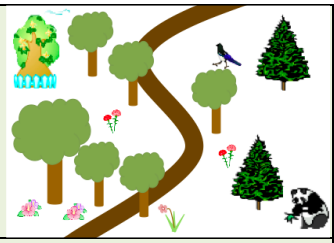
			
Species diversity and wildlife habitat	Multiple species of tree and shrubs 	A single species of tree 	
Recreation and spiritual experience	Low density of trails 	High density of trails 	
Municipality tax	50RMB	100RMB	
I would prefer: (Please tick as appropriate)	Choice A ○	Choice B ○	No choice ○

C2. Which of the following urban forest ecosystem services do you favor? Option C and option D would entail a cost to your household. No payment would be required for "Neither C nor D" option.			
	Scenario C	Scenario D	
Fresh water provision	Only softwood 	Only softwood 	
Noise reduction	Trees and shrubs	Trees and shrubs	

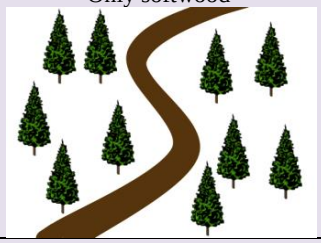
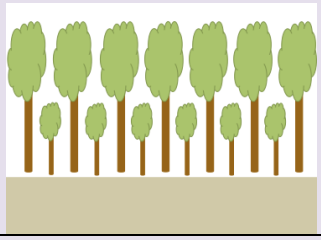
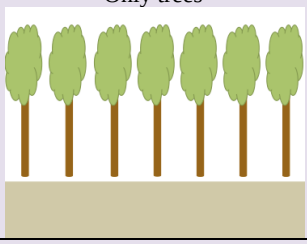
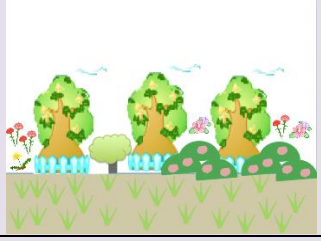
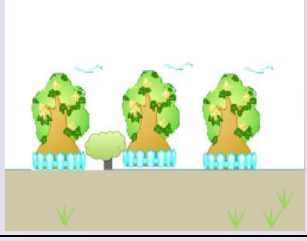
			
Moderation of extreme events (landslide)	Low-lying vegetation above 70% 	Low-lying vegetation below 30% 	Neither C nor D
Air quality regulation	Tree crown coverage below 25% (vertical view) 	Tree crown coverage below 25% (vertical view) 	
Species diversity and wildlife habitat	A single species of tree 	Multiple species of tree and shrubs 	
Recreation and spiritual experience	High density of trails 	High density of trails 	
Municipality tax	200RMB	25RMB	
I would prefer: (Please tick as appropriate)	Choice C ○	Choice D ○	No choice ○

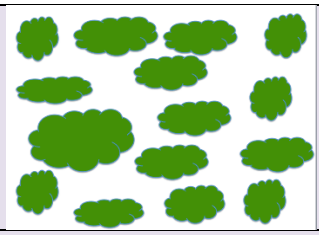
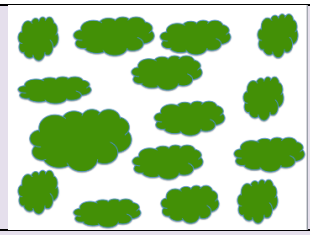
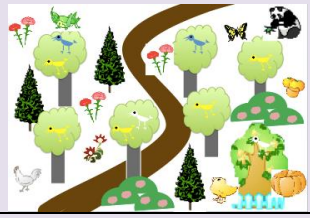
C3. Which of the following urban forest ecosystem services do you favor? Option E and option F would entail a cost to your household. No payment would be required for "Neither E nor F" option.

	Scenario E	Scenario F	
Fresh water provision	Only softwood 	Only hardwood 	Neither E nor F
Noise reduction	Trees and shrubs 	Trees and shrubs 	
Moderation of extreme events (landslide)	Low-lying vegetation below 30% 	Low-lying vegetation below 30% 	
Air quality regulation	Tree crown coverage 25%-75% (vertical view) 	Tree crown coverage above 75% (vertical view) 	
Species diversity and wildlife habitat	A single species of tree 	A single species of tree 	
Recreatio	Low density of trails	Low density of trails	

n and spiritual experience			
Municipality tax	50RMB	200RMB	
I would prefer: (Please tick as appropriate)	Choice E ○	Choice F ○	No choice ○

C4. Which of the following urban forest ecosystem services do you favor? Option G and option H would entail a cost to your household. No payment would be required for "Neither G nor H" option.

	Scenario G	Scenario H	
Fresh water provision	Only softwood 	Only hardwood 	
Noise reduction	Trees and shrubs 	Only trees 	
Moderation of extreme events (landslide)	Low-lying vegetation above 70% 	Low-lying vegetation above 70% 	Neither G nor H
Air quality regulation	Tree crown coverage above 75% (vertical view)	Tree crown coverage above 75% (vertical view)	

			
Species diversity and wildlife habitat	Multiple species of tree and shrubs 	Multiple species of tree and shrubs 	
Recreation and spiritual experience	Low density of trails 	High density of trails 	
Municipality tax	100RMB	50RMB	
I would prefer: (Please tick as appropriate)	Choice G ○	Choice H ○	No choice ○

(D) The following questions are about respondents' socioeconomic characteristics.

D1. Gender: 1) Male 2) Female

D2. Are you married?

1) Single → Please go D3. 2) Married (Including divorce, separation or death) → Please go D2-1.

D2-1. Do you have children under 20 years old? If you have, how many?

1) No 2) 1 3) 2 4) 3 and above

D3. What's your job?

1) Business/Administration (high-ranking civil servant, school principal)
2) Self-employed (small business with <9 employees, domestic workers, taxi drivers)
3) Expert/Professional/Freelancer (college professor, doctor, lawyer, artist)
4) Sales/Service Sector (storekeepers, salesman etc.)
5) Homemaker (someone who is mainly engaged in household chores)
6) Skilled Labor (electrician, carpentry, etc.)
7) Student
8) General (engineering-related field work, guard, caretaker etc.)

9) Office/Technical (office post, technical post, teacher)
10) Others (Please state: _____)

D4. Is your work related to environment or forest?
1) Yes (Which work, please state_____) 2) No

D5. What's your education level?
1) Elementary school graduate 2) Middle school graduate
3) High school graduate 4) University degree holder
5) Graduate school student / Graduate degree holder

D6. How much your household income per month?
1) Below 5000 (RMB) 2) 5000~9999 (RMB) 3) 10000~14999 (RMB)
4) 15000~19999 (RMB) 5) 20000~24999 (RMB) 6) 25000~29999 (RMB)
7) 30000~34999 (RMB) 8) Over 35000 (RMB)

D7. Have you ever lived in rural area?
1) Yes → Please go D7-1. 2) No → Please go D8.

D7-1 How many years have you lived in the countryside?
1) Below 1 year 2) 1-3 years 3) Above 3 years

D8. If you live in an apartment in Beijing?
1) Yes → Please go D8-1. 2) No → Please go "Survey Feedback".

D8-1 Do you own the apartment where you live in?
1) Yes 2) No

Survey Feedback

1. How well do you understand the information provided in the questionnaire?
1) Very Poor 2) Poor 3) Fair/Adequate 4) Quite Well 5) Very Well

2. If you have any other additional comments or feedback, please write them here:
_____
_____
_____
_____
_____

※ Thank you very much for your responses※
^_^

APPENDIX E Main Choice Experiments Survey (2017 October) (Chinese)

北京市民对城市林所提供的生态系统服务的偏好调查

서울대학교

您好！我是韩国首尔大学林业科学系的研究生。这是一份毕业论文的调查问卷，目的在于研究北京市民对城市林所提供的生态系统服务的偏好，旨在为城市林政策的制定提供理论依据，从而提高北京市民对城市林的满意度。问卷分为A，B，C，D 四个部分。由于调查的结果将直接影响到本次论文的结
论和质量，因此，恳请您认真填写。本次调查不会泄露您的任何个人信息，所得数据，只用做数据研究分析。非常感谢您的参与，祝您幸福安康，一切顺利！如果有什么问题，请毫不犹豫的联系我。

首尔国立大学 林业科学系 生态经济研究室 韩志颖敬上 (hanzhiying@snu.ac.kr)

版本1　　日期:

※ **现居地**
1.东城区、2.西城区、3.朝阳区、4.丰台区、5.石景山区、6.海淀区、7.顺义区、8.通州区、9.大兴区、10.房山区、11.门头沟区、12.昌平区、13.平谷区、14.密云区、15.怀柔区、16.延庆区

Q1.您的年龄是(截至2017年8月1日)： 满_____岁
-> 小于20岁调查请终止

Q2.您在北京的居住时间有多久(截至2017年8月1日)？ 满_____年
-> 少于1年调查请终止

※ 在回答问卷之前，请阅读下面有关城市林的说明。

城市林顾名思义城市中的园林，是供公众游览、观赏、休憩、开展科学文化及锻炼身体等活动，有较完善的设施和良好的绿化环境的公园林地。公园类型包括：综合性公园、居住区公园、居住小区游园、带状公园、街旁游园和各种专类公园等。

Q3.您在2016年至少去过一次公园林地吗?
1)去过 → 请接着回答问题A1　　2)没去过 → 请终止调查

(A)首先将对城市林的认识态度和使用情况进行提问

A1. 您在2016年平均每个月去多少次公园林地？　一个月_____次

A2. 您去公园林地的主要目的是什么？
请在下面的选项中排序前三名（第一：___，第二：___，第三：____）。
1)锻炼身体为健康　2)放松　3)促进友谊　4)欣赏自然美景　5)逃离日常生活
6)其它（请填写: _____）

A3. 您对您家附近的公园林地满意吗？
1)非常不满　2)不满　3)一般　4)满意　5)非常满意

A4. 步行从您家到附近的公园林地需要多久？
1)少于20分钟　2)20-39分钟　3) 40-59分钟　4) 60-120分钟
5)多于2个小时

A5. 您认为公园林地的范围充足吗？
1)非常不足　2)不足　3)中等　4)充足　5)非常充足

A6. 对比河流、农田和草地，您认为公园林地重要吗？
1)非常不重要　2)不重要　3)一样　4)比较重要　5)非常重要

A7. 您对北京的情感深吗？
1)非常不深　2)不深　3)一般　4)比较深　5)非常深

(B)下面是关于生态系统服务重要性的问题

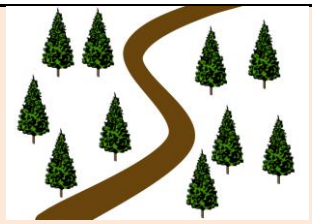
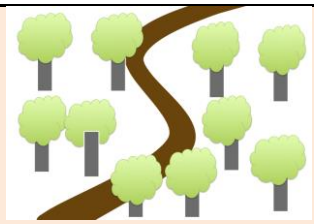
※ 在回答问卷之前，请阅读下面有关生态系统服务的说明。

生态系统服务（ecosystem services）是指人类从生态系统获得的所有惠益，包括供给服务（如提供食物和水）、调节服务（如控制洪水和疾病）、文化服务（如精神、娱乐和文化收益）以及支持或栖息地服务（如维持地球生命生存环境的养分循环）。

注意：生态系统服务之间有权衡关系。权衡关系是当一个生态系统服务功能增加，其它生态系统服务功能则下降。协同关系意味着一个生态系统服务功能增加，其他生态系统服务功能也跟着增加。当您选择时请考虑生态系统服务的权衡与协同关系。

城市林生态系统可以保护和净化水资源，对饮用水的供应起着非常重要的作用。阔叶林是北京新鲜水供应生态系统服务最大的贡献者。

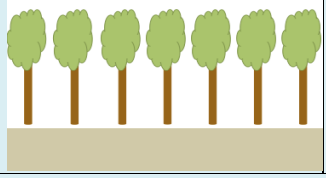
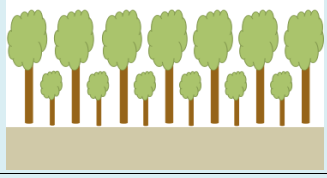
属性	提供新鲜水	
指标	阔叶树比例	
属性水平	如果只有针叶树，提供新鲜水生态系统服务水平较低。	如果只有阔叶树，提供新鲜水生态系统服务水平较高。

图解		

B1. 您认为提供新鲜水生态系统服务有多重要?

1) 非常不重要　2) 不重要　3) 中等　4) 比较重要　5) 非常重要

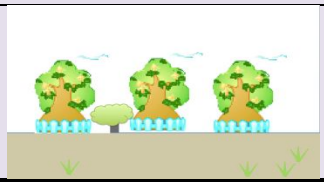
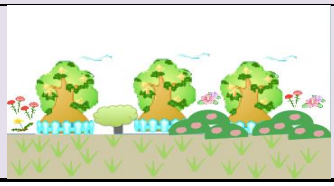
在城市林生态系统中，树枝和树叶能吸收噪音。此外，风通过松树、橡树的颤抖发出的声音可以降低噪音水平。在所有的植被带中，灌木由于其茂密的树叶和树枝是最有效地降低噪声的。

属性	减少噪音	
指标	植物构成	
属性水平	如果植物构成中只有树，减少噪音生态系统服务水平较低。	如果植物构成中有树和灌木丛，减少噪音生态系统服务水平较高。
图解		

B2. 您认为减少噪音生态系统服务有多重要?

1) 非常不重要　2) 不重要　3) 中等　4) 比较重要　5) 非常重要

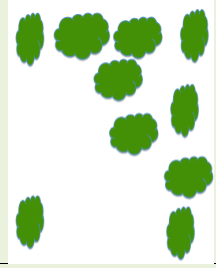
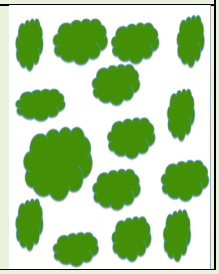
城市林生态系统可以减弱自然灾害的发生频率且减少极端天气造成的损失，包括洪水、暴风、海啸、滑坡等。林下植被通过维持土壤孔隙可以预防水土流失和山体滑坡。

属性	极端气候的调节（山体滑坡）	
指标	林下植被覆盖率	
属性水平	如果林下植被覆盖率是30%及以下，那么防止土壤流失和山体滑坡的生态系统服务功能较低。	如果林下植被覆盖率是70%及以上，那么防止土壤流失和山体滑坡的生态系统服务功能较高。
图解		

B3. 您认为极端气候的调节生态系统服务有多重要?

1) 非常不重要　2) 不重要　3) 中等　4) 比较重要　5) 非常重要

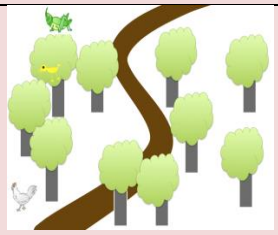
园林植物具有显著消减空气颗粒物(PM) 污染的作用，能有效地改善城市环境质量。城市林对减少空气污染有贡献，树冠覆盖率的大小对去除污染物有影响。

属性	空气质量调节		
指标	树冠覆盖率		
属性水平	如果树冠覆盖率是25%及以下，那么空气质量调节的生态系统服务水平较低。	如果树冠覆盖率在25%-75％之间，那么空气质量调节的生态系统服务处于中等水平。	如果树冠覆盖率是75%及以上，那么空气质量调节的生态系统服务水平较高。
图解(俯视图)			

B4. 您认为空气质量调节生态系统服务有多重要?

1) 非常不重要　2) 不重要　3) 中等　4) 比较重要　5) 非常重要

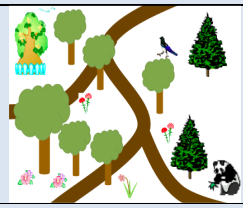
城市林生态系统为所有动物提供了生活必要品,如食品,水和栖息地。树种类越多，吸引的鸟类和动物就越多。当考虑物种多样性和野生动物的栖息地时，植物物种的数量可以作为城市林生物多样性的指标。

属性	物种多样性和野生动物栖息地	
指标	植物物种的数量	
属性水平	如果植物物种单一，那么物种多样性和野生动物栖息地贫瘠。	如果植物物种多样且有灌木丛，那么物种多样性和野生动物栖息地丰富。
图解		

B5. 您认为物种多样性和野生动物栖息地生态系统服务有多重要?

1) 非常不重要　2) 不重要　3) 中等　4) 比较重要　5) 非常重要

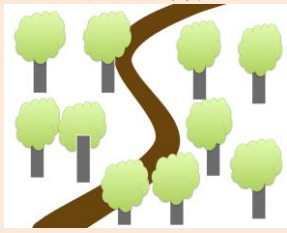
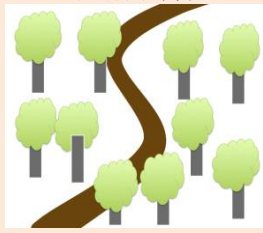
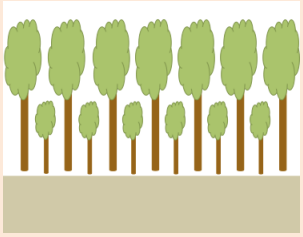
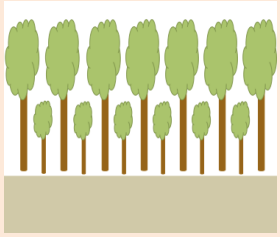
在公园林地上散步和锻炼身体是帮助人们放松非常好的方式。越来越多的人意识到在绿色空间
中可以保持身心健康。在韩国社会文化中小径被视为森林休闲基础设施的重要组成部分。森林的小径密度越大，越多的人可以享受娱乐和休养的城市林生态系统。

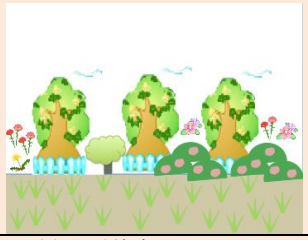
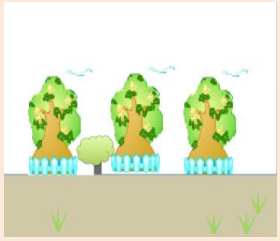
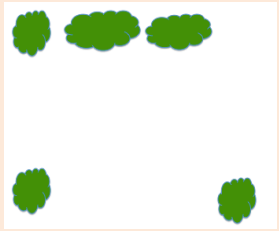
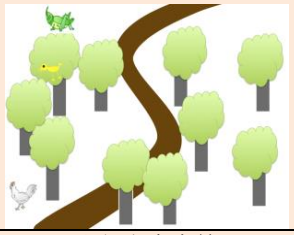
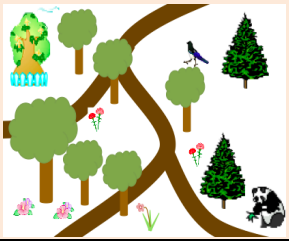
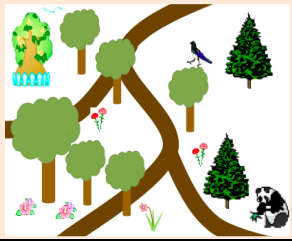
属性	娱乐和精神体验		
指标	山径密度		
属性水平	如果山径密度小，娱乐和休养生态系统水平较低。	如果山径密度中等，娱乐和休养生态系统处在中等水平。	如果山径密度大，娱乐和休养生态系统水平较高。
图解			

B6. 您认为娱乐和精神体验生态系统服务有多重要?
1) 非常不重要　2) 不重要　3) 中等　4) 比较重要　5) 非常重要

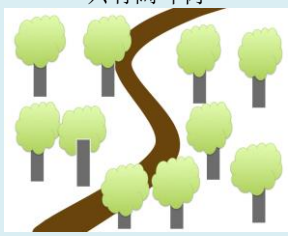
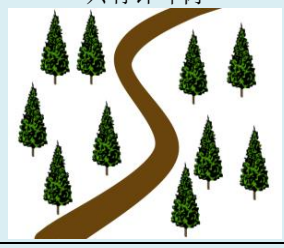
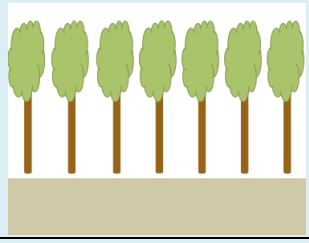
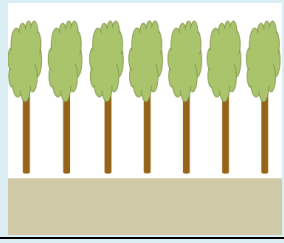
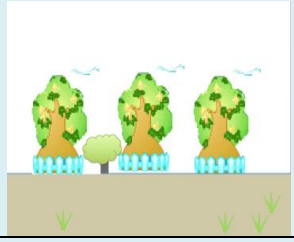
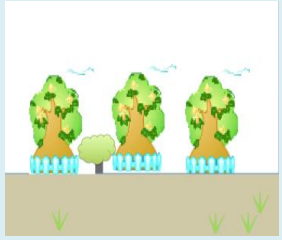
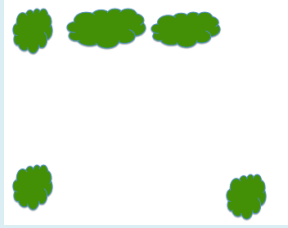
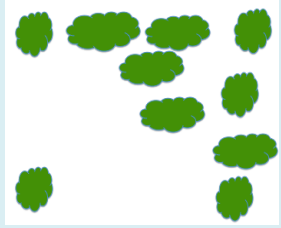
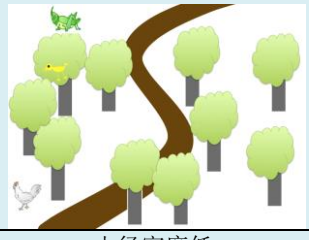
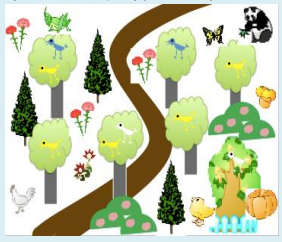
(C)下面是关于对城市林生态系统服务偏好的问题

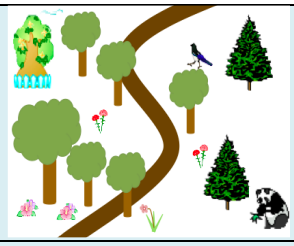
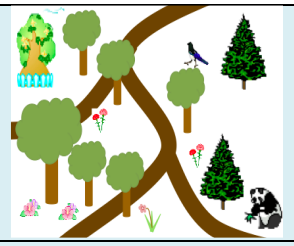
C1. 您支持下列哪个城市林生态系统服务的方案？选项A和B需要您家庭缴纳市政税。“不选”是不需要支付市政税且对方案A 和方案B都不满意。

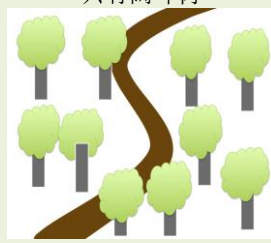
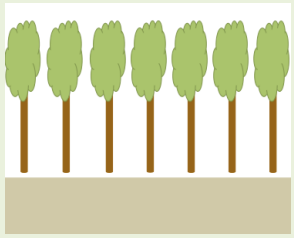
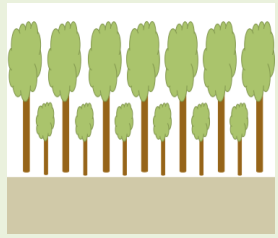
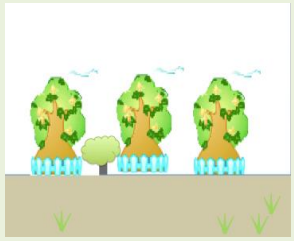
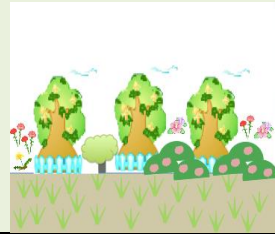
	方案 A	方案 B	
提供新鲜水	只有阔叶树 	只有阔叶树 	
减少噪音	有树和灌木丛 	有树和灌木丛 	

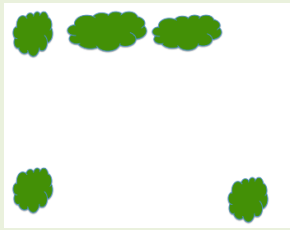
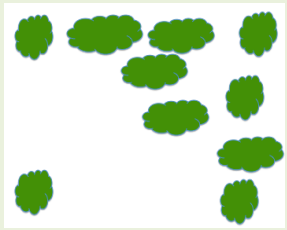
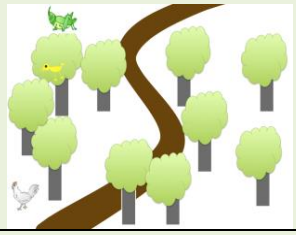
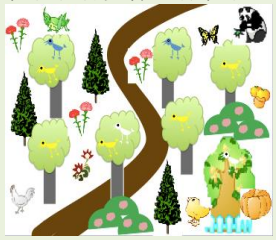
极端气候的调节（山体滑坡）	林下植被覆盖率70%及以上 	林下植被覆盖率30%及以下 	方案 A 和方案 B 都不选
空气质量调节	树冠覆盖率25%及以下（俯视图） 	树冠覆盖率25%及以下（俯视图） 	
物种多样性和野生动物栖息地	植物物种单一 	植物物种多样且有灌木丛 	
娱乐和精神体验	山径密度中等 	山径密度中等 	
市政税	50元 / 年	100元 / 年	
请在您认为合适的方案下划勾	选项 A ○	选项 B ○	不选 ○

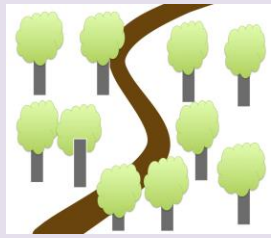
C2. 您支持下列哪个城市林生态系统服务的方案？选项C和D需要您家庭缴纳市政税。“不选”是不需要支付市政税且对方案C 和方案D都不满意。			
	方案 C	方案 D	

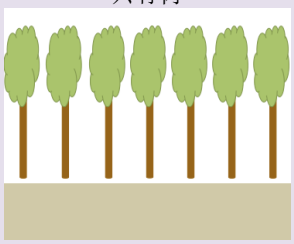
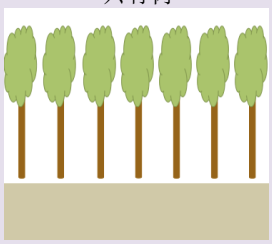
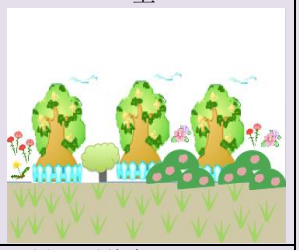
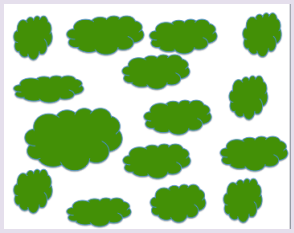
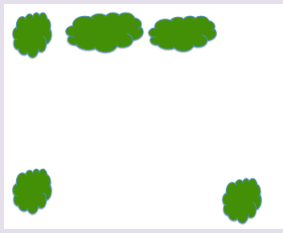
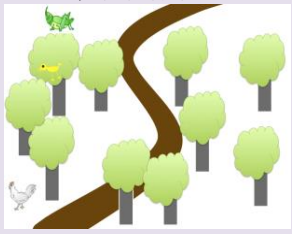
提供新鲜水	只有阔叶树 	只有针叶树 	方案 C 和方案 D 都不选
减少噪音	只有树 	只有树 	
极端气候的调节（山体滑坡）	林下植被覆盖率30%及以下 	林下植被覆盖率30%及以下 	
空气质量调节	树冠覆盖率25%及以下（俯视图） 	树冠覆盖率25%-75%（俯视图） 	
物种多样性和野生动物栖息地	植物物种单一 	植物物种多样且有灌木丛 	
娱乐和精神体验	山径密度低	山径密度中等	

			
市政税	25元 / 年	200元 / 年	
请在您认为合适的方案下划勾	选项 C ○	选项D ○	不选 ○

C3.您支持下列哪个城市林生态系统服务的方案？选项E和F需要您家庭缴纳市政税。“不选”是不需要支付市政税且对方案E 和方案F都不满意。			
	方案 E	方案 F	
提供新鲜水	只有针叶树 	只有阔叶树 	
减少噪音	只有树 	有树和灌木丛 	
极端气候的调节（山体滑坡）	林下植被覆盖率30%及以下 	林下植被覆盖率70%及以上 	方案 E

空气质量调节	树冠覆盖率25%及以下（俯视图） 	树冠覆盖率25%-75%（俯视图） 	和方案 F 都不选
物种多样性和野生动物栖息地	植物物种单一 	植物物种多样且有灌木丛 	
娱乐和精神体验	山径密度低 	山径密度低 	
市政税	100元 / 年	25元 / 年	
请在您认为合适的方案下划勾	选项 E ○	选项 F ○	不选 ○

C4. 您支持下列哪个城市林生态系统服务的方案？选项G和H需要您家庭缴纳市政税。“不选”是不需要支付市政税且对方案G 和方案H都不满意。			
	方案 G	方案 H	
提供新鲜水	只有针叶树 	只有阔叶树 	

减少噪音	只有树 	只有树 	方案 G 和方案 H 都不选
极端气候的调节（山体滑坡）	林下植被覆盖率70%及以上 	林下植被覆盖率70%及以上 	
空气质量调节	树冠覆盖率75%及以上（俯视图） 	树冠覆盖率25%及以下（俯视图） 	
物种多样性和野生动物栖息地	植物物种单一 	植物物种多样且有灌木丛 	
娱乐和精神体验	山径密度中等 	山径密度低 	
市政税	25元 / 年	200元 / 年	
请在您认为合	选项 G ○	选项 H ○	不选 ○

适的方案下划勾			

(D)以下是有关应答者社会经济特性的问题

D1.您的性别：1）男　　2）女

D2.您目前的婚姻状态是：
1）未婚 → 请接着回答问题D3
2）已婚（包括离婚、离异、丧偶）→ 请接着回答问题D2-1

D2-1.您有未满20 岁的孩子吗？如果有，有多少？
1）没有　　2）1　　3）2　　4）3 个以上

D3.您目前所从事的职业是：
1）管理（高级公务员、学校校长等）
2）个体经营（小型企业职工小于9人、出租车司机等）
3）专家/职业性/自由职业者（大学教授、医生、律师、艺术家等）
4）销售/服务部门（店主、推销员等）
5）家庭主妇
6）技工（电工、木工等）
7）学生
8）普通工作者（工程有关的现场工作、警卫等）
9）办公室/科技（办公室职员、科技人员、老师）
10）其它（请填写：_____）

D4.您的工作和环境或者林业有关吗？
1）有关（什么工作，请填写_____）　　2）没关

D5.您的学历是：
1）小学及以下　2）初中　3）高中　4）大学　5）研究生及以上

D6.您的家庭平均月收入是多少？包括年终奖和其他收入，请选择总的家庭月平均收入。
1）5000元以下　　2）5000-9999元　　3）10000-14999元
4）15000-19999元　　5）20000-24999元　　6）25000-29999元
7）30000-34999元　　8）35000元及以上

D7.您曾在农村居住过吗？
1）居住过 → 请接着回答问题D7-1.　2）没居住过 → 请接着回答问题D8.

D7-1 您在农村居住了多少年？
1）1年 以下　　2）1-3年　　3）3年以上

D8.您在北京是否居住在楼房（公寓）里？
1）是的 → 请接着回答问题D8-1
2）不是 → 完成了问卷，请接着填写 “调查反馈”

D8-1 您拥有所居住楼房（公寓）的产权吗？
1）有　　2）没有

调查反馈

1. 您对问卷中所提到的信息理解程度是怎样的?
   1)完全不了解　2)不太了解　3)一般了解　4)比较了解　5)非常了解

2. 如果您有任何问题，请写在这里：

_____
_____
_____
_____
_____

※ 非常感谢您的参与※
^_^

국 문 초 록

도시림 생태계 서비스에 대한 시민의 선호도

- 중국 베이징을 대상으로

한지영(HAN ZHIYING)

산림과학부 산림환경학 (Forest Environment Major)

College of Agriculture and Life Science

Seoul National University

이 연구는 다양한 대중의 요구를 충족시키고 생태계 서비스의 분배와 공급을 개선하기 위한 정책 옵션을 제공하며 북경의 풍부한 생태계 서비스에 관한 도시근교림(urban forest)의 대중적 선호도를 분석하는 것을 통하여 정책 입안자와 생태계 수혜자 간의 갈등을 최소화하는 목적으로 한다. 문헌 조사 및 전문적인 델파이 방식(Delphi method)은 18가지 생태계 서비스의 중요성을 평가하고 도시 숲의 생태계 서비스를 담수 공급(fresh water provision), 소음 감소(noise reduction), 극심한 사건의 절제(Moderation of extreme events), 공기의 질

규정(air quality regulation), 종 다양성과 야생 생물 서식지(Species diversity and wildlife habitat), 레크리에이션과 영적 경험(Recreation and Spiritual Experience) 6가지 범주로 분류하기 위해 채택되었습니다. 주요 옵션에 관한 실험 조사는 2017년 10월에 실시되었으며 총 483건의 유효 조사가 분석되었습니다. 이 실험의 대상자는 19세 이상이고 베이징에 1년 이상 거주하며 2016년에 한 번 이상 베이징에 있는 도시근교림 중 하나를 방문한 시민들입니다. 조사 결과는 다음과 같습니다. 첫째, 공기의 질 조절은 베이징 시민에게 도시근교림을 선택하는 데에 가장 영향력을 미치는 생태계 서비스로 간주됩니다. 베이징 시민들은 낮은 수준에서 중간 수준으로, 중간 수준에서 높은 수준으로 공기의 질을 개선하는 숲을 조성하는데 매년 85위안 및 264위안을 지불할 의향이 있는 것으로 나타났습니다. 둘째, 월 소득이 높은 시민들이 도시 숲 조성을 위한 비용을 더 많이 지불할 의향이 있습니다. 셋째, 아파트를 소유한 사람은 아파트를 소유하지 않은 사람에 비하여 지방 세에 대한 지불의사가 더 있는 것으로 나타났습니다. 결과적으로 말하자면, 시민들이 공기의 질을 개선하는 데에 기여하기 위해 세금을 기꺼이 지불할 의사가 있으며 도시근교림 사용자를 만족시키는 목적으로 도시근교림을 설계하고 관리하기 위하여 공기의 질 조절에 효과적인 도시 숲을 조성 관리하는 정책이

필요합니다.

주요어 : 도시 숲, 생태계 서비스, 신민 선호, 선택 실험, 베이징

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